Industrial QUALITY CONTROL

Vol. XIV, No. 9
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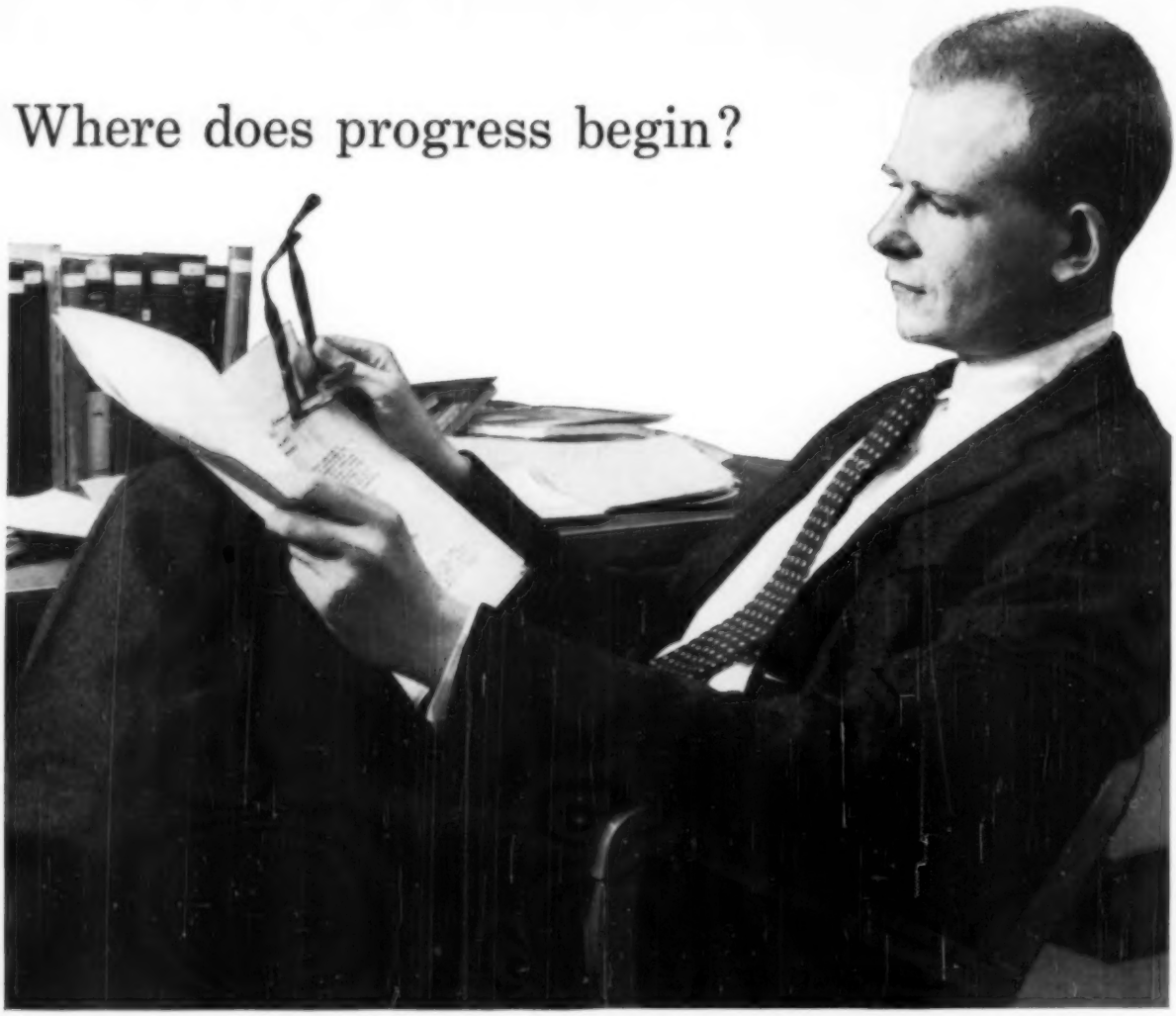
QUALITY
through
Scientific Methods

Journal of the
AMERICAN SOCIETY FOR QUALITY CONTROL

Where does progress begin?



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graduate of the Laboratories' Communications Development Training Program.

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From the President's Desk

We *Need* the Dues Increase!

For some time now your officers and directors have cited the need for an increase in membership dues to meet the requirements of both the increased costs of operating and the increased services being performed by your Society. The problem is a sticky one because no one wants to pay more dues than he really has to. I wouldn't vote for a dues increase either unless I were convinced it was really needed.

And the truth is, it is needed—urgently. Why? Well it's as simple as this:

> Our normal operating expenses have grown faster than our normal operating income, so that for the past couple of years we have had to dip into our reserves to make up the red-figure difference.

And there you have it. This can't go on indefinitely. Something has to be done to balance the normal operating income and expenses. And in the opinion of your officers and board of directors one of the necessary courses of action at this time is to increase membership dues.

Please note that I have purposely used the term "normal operating" in describing our income and expenses because this is not a temporary situation but represents a real growth in level. If you'll take a quick look at our operating statements in your September issue of *Industrial Quality Control*, you'll notice that during the five years since 1951-52 the level of your Society operating expenses exclusive of the annual convention has increased from $41,500 to $148,000—a growth of 350%—and this year's budget is $158,000.

This is a natural growth due to several major expansions in personnel and services such as the employment of our administrative secretary and managing editor, the increase of *Industrial Quality Control* from a 32-page bi-monthly to 40 pages every month, punched card membership records, and the establishment of our offices on a reasonable business basis, without excessive reliance on volunteer help. The cost of publishing this magazine is $6.43 per member. Our administrative operations run to $5.36 per capita. The Convention costs last year were $3.88 and other miscellaneous expenses ran to $0.91 for a total of $16.58 per member. Yet we only collect $6.00 per member from your dues of $10.00. The difference has had to come from other areas.

During the same period our major sources of income have only increased as follows: membership dues 165%; advertising 230%; library subscriptions 370%, technical literature sales 240%. As you can readily see, membership dues has not kept pace! The slight increase in dues income is solely the result of growth in number of members since there has been no change in dues since 1950, while that of advertising has been due both to increased space and increased rates. Obviously neither has caught up to the increase in operating expenses and both need to be increased further.

Last year as you know, the dues increase amendment failed to pass by less than 1% of the voting members. As a result we had to ask the sections for contributions to help us over this year's operations. We are indeed grateful to those sections and divisions who rallied to our assistance so admirably, but they will be the first to agree that we can't very well pass the hat like this every year.

One of the objections that was raised was the fact that we have plenty of reserves so why worry about increasing dues as long as we have these kinds of funds. This is a perfectly rational thought, but stop and think for a minute what this "money in the bank" represents. Our surplus serves two main functions—money for growth and a cushion against bad times. When we used it for such one-shot items as consolidating the offices in Milwaukee and converting the membership records to punched cards, there is no question but what this was appropriate usage for *growth*. But I think everyone will agree that the operating deficits of the past couple of years, for which we also had to go to our surplus, cannot be laid to bad times.

The present size of our surplus—roughly $90,000—may tend to make some of us complacent. In terms of personal finances, this might seem like a tidy sum. But your Society must operate as a successful and stable not-for-profit business. For safety it is generally agreed that the surplus should be equal to at least one year's expenses—not to finance us through only one year, but possibly several years of low-income operations due to bad times. With a budget of $158,000 this year, you can readily see that we don't have to worry about having too much surplus for some time to come.

With these thoughts in mind I sincerely hope that you can now see why an immediate dues increase is something we urgently need. It is only one of several necessary actions we are taking at this time to stabilize our operations. So when you vote on the amendments with your annual ballot for officers next month, be sure to vote yes for the dues increase. Your "yes" vote will provide assurance of a strong society with a sound financial foundation.

Sincerely,

Leon Bass

The Technical Aspects of Quality Control

CHARLES A. BICKING

The Carborundum Co., Niagara Falls, N. Y.

Introduction

QUALITY CONTROL was considered as a technical aspect of manufacturing for many years before the appearance of Shewhart's books[1] in 1931, although its publication dates exactly the birth of the science as we know it. This birth date stands out clearly in the author's memory because of an assignment as a student to the task of analyzing the quality control function in manufacturing. The report resulting from the assignment is dated December 1930, only a few months before Shewhart's book appeared. There are twenty-eight items in the bibliography appended to the report, but a student of today probably would not recognize any of the authors, with the possible exception of G. S. Radford. Radford, incidentally, was the precursor of Shewhart, and his book,[2] written in 1922, is an early classic. Not one of the titles in the bibliography suggests any statistical content. Although the oldest article,[3] one on inspection, is dated 1915, the term "control of quality" does not appear earlier than 1917, when it appears in the title of an article by Radford.[4] One interesting looking title in the list was "Foolproof Control of Quality."

Re-reading the report on quality control, as it was known prior to 1931, does not disclose much that would be useful to the quality control engineer of today. There was clear recognition of a technical problem but quality control, in those days, used techniques now outmoded, which relied on sorting out bad material by careful inspection. There were many good ideas applied but the emphasis is entirely different in modern statistical quality control.

Elements of the Technical Problem of Quality Control

There are a number of technical elements in the problem of quality control as we see it today. Stepwise attention to each of these elements is essential. Each step requires the application of technical ability of the highest order. No aspect may be neglected and none of the real responsibility may be delegated to sub-professional levels. The essential steps for a successful program are summarized in the following table. Each step will be discussed in some detail.

Technical Elements of Quality Control

1. Validation of the Data
2. Establishment of Baselines
3. Development of Procedures
4. Application of Procedures
5. Coordination with Engineers and Designers
6. Review of Quality Control Operations

Validation of the Data

The success of a quality control program depends upon the validity of the data upon which the program is based. This requires, at a very early stage, a review of test procedures and of instrumentation. Even by using modern methods of analysis, you cannot extract more value from the data than they actually contain. If the test method produces data of little value, we may be led to false conclusions and wrong decisions.

The amount of information in data depends upon its validity and its pertinence. Valid data are precise and accurate, or unbiased. Precision is related to the variability of the individual measurements and accuracy is related to the difference between the observed average value and some well established or standard value. Pertinence is related to the bearing which the information in the data has on the problem to be solved.

In a presentation in connection with a quality assessment program for U. S. Army Ordnance, Munro* gave the following interesting example of these concepts.

Suppose that we ask a qualified inspector to measure five hundred new half-inch Johannsen blocks using the best micrometer from his tool bench. The result might be an average value and spread as follows:

$$\bar{X} = 0.4993 \text{ inch}$$

$$\sigma = 0.0001 \text{ inch}$$

However, the blocks are so carefully finished that we know that the true average dimension is 0.50000 inch, to at least this number of decimal places. If we had concluded from the inspector's measurements that the true average was within 0.4993 plus and minus a small quantity and that the economic tolerance spread for manufacture was something like 0.0006 inch, we should have been completely wrong. We should have forgotten the simple fact that measurements are always subject to error; that they are a human being's impression of the response of an instrument to the true value. In the example, it is obvious that the variation in our data (represented by $\sigma = 0.0001$ inch) and the bias ($0.50000 - 0.4993 = 0.0007$ inch) are due to the inspector and the micrometer.

If the real purpose of our measurements were to determine the dimensions of the Jo blocks, none of the information in the data was pertinent. However, if the purpose had been to estimate the imprecision and bias due to the inspector and micrometer in order to determine their effect on data from a manufacturing operation, then our data would have been valid.

*Dr. Sutton Munro, Bell Telephone Laboratories, New York.

Establishment of Baselines

The next logical technical step is analysis of the available data to establish a baseline for purposes of comparison and measurement of progress. Since the basic aim of a quality control program is the reduction of costs, it is important to determine what losses exist and where they are concentrated. An estimate should be made of how much these losses may be reduced and a goal should be set for each manufacturing department. A time-table should be set up and the responsibilities of various departments should be defined. Methods should be devised for recording progress and for reviewing and reporting results. All this adds up to the necessity for a clear program, agreed upon in advance.

From the standpoint of the quality level and uniformity of the product, baselines may be established by calculating preliminary control chart limits for data from some earlier period of reasonably satisfactory operation. Detailed explanations of how to go about this are available in the many textbooks and manuals that have been written on statistical quality control. An unusual example* may serve to show how an analysis of what might be done led to the successful application of control procedures.

Loaded 105-mm projectiles comprising a lot are customarily grouped by weight into three zones each of which is seven-tenths of a pound wide. (See Fig. 1.) Firing corrections are made, while using the lot, assuming the weight of each projectile to be at the center of its zone. It would be desirable to have the weights in each zone distributed normally and with a minimum spread about the center.

However, in one lot studied, although the weights were fairly well controlled statistically, the average weight was significantly higher than the center of the middle zone and the standard deviation was 0.165 pound. Thus the total control limit spread was nearly a pound and a substantial percentage of projectiles were in the highest zone and a small percentage in the lowest zone. This meant an unfavorable distribution in the middle and completely unsatisfactory distributions in the other two zones. Furthermore, the necessity to classify the lot among three zones resulted in sub-lot sizes inconveniently small for use in the field.

The average weight of the shell in the highest zone was quite close to the lower boundary of that zone, so that firing them on the basis of zone mean weight would be little better than on the basis of the mean weight of the middle zone.

This was even more true of the smaller number of shells in the lowest zone. The solution was to control shell weight a little better so that all shells could qualify for a single zone. This was done by inducing the various manufacturers of shell bodies to install statistical quality control procedures on the production lines. Most manufacturers soon were able to improve their process to the extent that control limits were within one of the original weight zones. As long as such control was maintained, the practice of zoning could be dispensed with. One of the outcomes of the quality control program on 105-mm rounds was an increase in lot size of uniform shell in one zone from about 4,000 to 150,000.

*Example from the Ordnance Quality Control Project on 105-mm Complete Rounds.

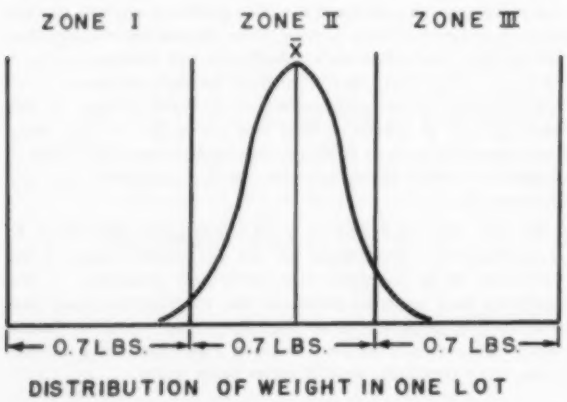

Figure 1—Diagram of Weight Zoning of 105 MM Shells

Development of Procedures

Based upon the preceding steps, (validation of the data, and establishment of baselines) detailed quality control procedures may be developed. Ideally, the quality control program should be evolved at the time the manufacturing specifications are being developed. Actually, most quality control programs have to be installed into a going operation. The difficulty of this step may have been somewhat under-emphasized in the early days of enthusiasm over statistical quality control. We simply cannot send a boy to do this man-sized job. Although the control chart is a relatively simple device, its fruitful application is, in most industries, a highly technical operation.

For example, during the last war early attempts to apply standard control charts to ballistic properties of small arms ammunition ran into difficulties. It was observed that even when standard lots of ammunition were used it was very difficult to maintain control, based on within-day variability, from day to day. Ammunition experts declared that they had never seen a laboratory which was able to maintain control on this basis. Yet the range of a group of ten rounds fired at the same time seemed to quality control engineers to be a rational basis for control of averages of groups of this size fired on different days. For a long time, the argument raged back and forth while most ballistic ranges continued to rely on the old-fashioned direct comparison of a series of production rounds with a series from the standard lot.

Finally, however, one of the better laboratories, guided by control chart studies, began to investigate assignable causes for day-to-day variability. It soon turned up a number of very interesting facts about the sensitivity of results to small changes in the daily adjustment of equipment. It was found that the placing of chronograph screens and the calibration of the electronic measuring equipment was much more important than had been realized. Not only was greater care exercised after that in the preparation for firings but better set-up techniques were devised. All of this resulted, eventually, in the ability of this laboratory to maintain day-to-day control on the basis of within-day range. However, it is worth noting that straightforward application of control charts was impossible until the need for some procedural changes was realized.

There is another important type of process control problem which requires modification of standard control chart procedure. It involves the control of materials made in strips or sheets. Some of the approaches tried have not been widely publicized, for example the unique method of sampling and charting used in sheeting of smokeless powder for mortar increments which resulted in a reduction of 21% in the cost of manufacture within

one year. That method involved making measurements at experimentally selected positions in a geometric pattern covering the whole uncut sheet. These within sheet measurements were then used as the rational subgroup on which to base calculation of limits for control of the average properties of the sheets. For strip steel, the problem has been discussed ably in the pages of *Industrial Quality Control*.[5] For paper or paper-board the author made several suggestions in a recent article.[6] A brief discussion of the latter problem may help to clarify the arguments for careful development of quality control procedures to meet the special requirements of a process.

The usual procedure followed in setting up control charts would, in the case of paper machine control, call for a set of limits for averages of the tests made at the end of each reel of paper and for ranges of these tests. Both sets of limits might be based on the average range of the measurements taken across the paper web for each reel. There are valid objections to average chart limits set in this way because engineering considerations suggest the possibility that the cause systems which operate across and along the web of paper are not the same. Therefore, it has seemed most satisfactory to use a different basis for the control limits for reel ranges than for reel averages. Thus, the quality control engineer is faced with the problem of developing suitable quality control procedures.

There may be objections in some cases to using unadjusted cross-machine ranges even for control across the machine. These objections are due to the frequent occurrence of bias in measurements from side to side of the paper machine. Cross-machine bias may result in an observable and even in a significant pattern and must be taken into account when control procedures are being developed. Depending on the situation, standard range charts with $D_3\overline{R}$ and $D_4\overline{R}$ limits, with or without adjustment for bias, may be used for cross-machine control.

Control limits that are very narrow result when average charts arrived at in the conventional way are used. Moreover, the data often indicate cyclic and other types of instability typical of uncontrolled processes. Many of these disturbances arise from the way the operators handle the paper machine or from variations in the preparation of pulp and are not inherent in the machine itself. On the premise that the causes of large variations should be corrected first, a control chart is needed that will point out the gross human errors or changes in the pulp and which will show gradually narrowing limits as more and more assignable causes are identified and removed.

The use of moving range of consecutive reel averages as a basis for chart limits is a successful expedient. It has some faults, principally because of the relatively long time that usually elapses from one reel end to the next. However, it makes possible corrective action in realistic sequence to arrive at an *a priori* engineering objective that makes sense. It is a rational method of sub-grouping. It is capable of bringing the process into control safely within specifications. The individual reel end averages are plotted as individual values with appropriate limits. This is done so that the state of control may be examined as each reel is finished. Two sigma limits for the reel end average chart are obtained from $\overline{\overline{X}} \pm 1.77\ \overline{R}_M$, where $\overline{R}_M$ is the average moving range of consecutive pairs of reel averages.

In this application, reel end averages are treated as individual values. The formula is derived from the standard formula for limits for control charts of averages, as follows:

$$\text{Standard limits: } \overline{\overline{X}} \pm A_2\overline{R}$$

Multiply A_2 by $\frac{2}{3}$ to convert from three-sigma to two-sigma limits. Use A_2 for sub-groups of two because $\overline{R}_M$ employs ranges of consecutive values. Multiply A_2 by the square root of two to convert from limits for averages to limits for individuals. Then $\overline{\overline{X}} \pm \frac{2}{3}\ (1.88\ \overline{R}_M\ \sqrt{2}\ ) = \overline{\overline{X}} \pm 1.77\ \overline{R}_M$.

The final process control procedure calls for a chart for cross-reel ranges based on the average range across the reel and a chart for reel averages based on the moving range of the averages.

Installation of Procedures

The installation of the finished quality control procedures is very largely an educational activity. It is an important step from our viewpoint because it is largely technical education that is required. An educational program should be laid out using all the organization's facilities. Management must be briefed, concisely and informatively. Supervision must be given a good background in the technical and psychological aspects of modern quality control. The quality control staff must be kept abreast of the best available techniques by adequate, continuing training. Incentives for quality workmanship must be provided which will be attractive to foremen and operators.

Producibility Engineering

In the years B.S. (before Shewhart), it was a maxim that the quality control man was not a trouble shooter. Quoting from the author's 1930 report:

> "The inspection department should not be engaged in activities which are not closely connected to inspection. Counting, grading and repair are connected directly with the inspection of goods in process. Trouble shooting is beyond the capacity of the average inspection department."

More recently, there has been a tendency for the quality control man to look upon himself as a trouble-shooter. As a matter of fact, trouble-shooting sometimes occupies too much of his time. The point that should be considered is that quality control results should be used to improve producibility of the product. This involves both engineering for producibility and redesign. Close cooperation is required with the plant engineering department to correct design oversights. A good relationship between quality control and engineering is a mark of a successful quality control manager.

In one such instance known to the author, a major part of the energy of the quality control department was put on cooperation with the engineering department in improving producibility. This even went so far as helping the engineering department to put on courses for training engineers in the experimental uses of statistics. One of the best known quality control engineers in the country was a consultant on this project.

Product Redesign

Actual redesign is, of course, outside of the province of the quality control activity. However, quality control results must be fitted in with other data to bring about continual improvement in the product. This has

become more and more important as the end items of manufacture have become more and more complex. This is a very important consideration in improving the reliability of much of the complex military equipment now in development. The quality control activity should begin with the design and coordinate with all subsequent engineering, production, acceptance, and surveillance testing.

Review of Quality Control Operations

A procedure must be established for the periodic review of the quality control operation. Formal procedures must be kept up to date. Lagging applications must be revitalized. New ideas must be injected constantly. The whole program must be kept active like any other plant program, such as the safety program, and must be just as constantly re-energized.

Conclusion

This article has pointed out some of the technical elements in modern quality control but has scarcely mentioned the statistical techniques that must be used. It must be apparent, however, that today's quality control engineer must have many tools in his kit in addition to the basic control charts. For the validation of data and the development of procedures, in particular, many of the more rigorous experimental techniques may be needed before routine control can be imposed. Significance tests or correlation techniques may be necessary to measure the significant relationships in existing data or analysis of variance may be required after data have been acquired in a statistically designed experiment.

A number of years ago Shewhart and others pointed out that quality control engineers should increase their emphasis on the use of statistical experimental techniques. The trend in this direction has been very noticeable in recent years. Although a number of useful publications have appeared, there is still room for a work on experimentation in industry which can measure up to the earlier classics by Radford and Shewhart.

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AUDIT TESTING

A Sound Investment

C. W. CARTER and LAWRENCE C. PAULSON*

Introduction

The title may suggest to the reader a double interpretation. First, this article is a discussion of a particular type of testing. Secondly, it is a suggestion that all testing should be audited. Most managements will agree that it is worth a nickel to know that a dollar's worth of test results are correct.

What is meant by *Audit Testing?* According to Webster, an audit is a "general and formal examination." Used in this connection, then, it means a periodic examination of routine testing to assure that it is being done when and as specified. Duplicate samples, selected at random, are run by the routine Tester and the Test Auditor. If the results differ by a larger amount than can be statistically attributed to pure chance, a careful on-the-spot study is run to determine the reason or reasons for the difference. Such a program, in operation at the International Falls mill of the Minnesota and Ontario Paper Company, will be described here. Although slanted particularly at the paper industry, it is felt that these techniques have considerable applicability to other industries.

The Background

Such a program did not happen just by chance. Perhaps the roots from which this activity sprang lay in the question, "What is the function of testing?" This has a threefold answer:

1. To provide the operator with information which forms the basis for taking action to minimize or even forestall the manufacture of sub-standard product.
2. To give both operator and technical personnel information for diagnosis and analysis. Although after-the-fact, this can be often useful in safeguarding against future troubles.
3. Acceptance of material for further processing or shipment.

It is pertinent here to emphasize that the action taken and the analysis of trouble can be no better than the data upon which it is based. It, therefore, becomes extremely important that the data obtained be of sufficient accuracy to lead to the correct decision. Of equal importance is the requirement that the total amount of testing be within the budgetary limits.

There are, however, two circumstances—not necessarily peculiar to but found in the paper industry—which make sampling and testing a real problem. First, there is the difficulty of obtaining a random sample. For example, paper coming from the machine is wound until the roll reaches a certain diameter. It is then broken off and a new roll

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started. A random sampling plan might call for testing the 1523rd yard. However, this might well come somewhere between the beginning and end of a roll. The result of this impasse is a practical compromise whereby the end of the roll is assumed to be representative.

Also, the sampling and testing of stock and furnish at the different stages of manufacture is traditionally set so that an inspector may have a fixed schedule. This routine type of control, although easy to administer, has an element of inflexibility and does not always readily adapt itself to changing quality needs.

The second peculiarity is that testing in a paper mill is carried on by two and sometimes three responsibilities. Many tests are performed by production personnel, although the majority are done by inspectors and laboratory testers. This different responsibility always gives rise to differences in sampling and testing procedures; indeed, sometimes in test equipment. It also tends toward slower communications, which hamper the effectiveness of a testing program.

These, then, offer challenges to a paper testing program, which must be met on some basis consistent with quality and cost if the testing effort is to be justified.

The Approach

As a first step in solving any problem, it is advisable to get the facts. This was done by conducting a testing survey, which embraced all testing in the mill. The procedure here employed was to compile a list of tests by departments, using the form shown in Fig. 1. This basic tabulation is composed of four general headings, each with subject matter as follows:

1. **Test**
   For each department was developed a complete list of quality characteristics tested. This was accomplished through talks with production supervision, testers, inspectors and technical personnel. The survey included all production departments from the Wood Room through Shipping.
2. **Sampling**
   This heading describes the method of obtaining the sample. Under the sub-column headed "where" was entered the location of the sampling point. Next, the "Frequency" of sampling a process (i.e., once per shift, every hour, once a reel, etc.) was entered. "By Whom" and the "Number of People" helped to identify the responsibility for obtaining the sample. Finally, the "Time Required", although only an approximation, was useful in comparing the total time spent in sampling with the relative importance of a given characteristic. It should be here emphasized that no effort was made to "time-study" this activity.
3. **Testing**
   Here again, the location ("Where"), responsibility ("By Whom"), and the amount of effort ("Time Required") were entered. These allowed comparisons with the sampling activity, and just listing these side by side brought out several suggestions for strengthening, consolidating, and improving the effectiveness in specific cases.
4. **Results**
   Whereas the first three headings were susceptible of very factual treatment, this was more a compilation of subjective judgments. These were arrived at through detailed talks with production and technical personnel and by observing the use to which test results were put. Several parties might use a particular test and the "Action Taken" would differ according to the user. As a guide to the evaluation column "Effective for Control" a series of ground rules were established and discussed with the persons concerned. This classification as shown implied the alternative of "Not Effective for Control." During the course of the survey, this was moderated to the classifications suggested by the first two functions of testing (see section on The Background). These might be paraphrased "on-the-spot action" and "after-the-fact analysis". It is apparent that a test falling into the first classification will certainly fit the second. A test used for on-the-spot action (e.g., headbox pH) may also be used for analysis purposes later. However, the converse is not necessarily true. Beater Value, for example, is not used for making any on-the-spot adjustments, but is studied by operating personnel as being indicative of the general run of wood and quality of pulp. It was also stressed that classification under the second description did not imply the recommendation to eliminate or reduce the frequency of a given test.

INTERNATIONAL FALLS PLANT

QUALITY CONTROL DEPARTMENT

Survey of Testing

Department_____

	Sampling				Testing				Results		
Test	Where	Frequency	By Whom # People	Time Required	Where	By Whom # People	Time Required		Who Uses Results	Action Taken	Effective For Control? If Not-Why?

Figure 1—Survey Testing Form

During the course of this fact-finding phase, many changes were suggested by participating personnel. Some were implemented immediately, others were discussed in general supervisory meetings. Through careful study of the data, further opportunities for strengthening the testing were uncovered. Being somewhat less obvious, these required considerable discussion before arriving at satisfactory recommendations.

Results

The testing survey proved to be a many-sided document. The broad recommendations were as follows:

1. That certain sampling and/or testing procedures be changed to obtain more accurate results.
2. That statistical process control limits be established in order that the tester may notify the appropriate authority when tests are beyond limits.

TYPICAL PAGE FROM TESTING MANUAL

Sulfite Mill

No.	Test	Sampling Where	Sampling Frequency	Testing Where	How Results Are Used
1.	% SO_2 Gas Test TAPPI 603 M - 45	From gas line off coolers	Once every two hours	Acid Plant	This test is used for checking the automatic Leeds & Northrup SO_2 recorders.
2.	Temperature of gas, strong tower and weak tower M & D Method		Once per hour	Acid Plant	The Acid Maker controls the temperature of the gas, the strong tower, and the weak tower to regulate the speed of the gas absorption in the acid making process.
3.	Acid test, total, free, and combined SO_2 TAPPI 640 M - 45	From strong and weak towers	Once per hour	Acid Plant	This test tells the Acid Maker how much lime rock to use. He adjusts the amount of water and gas going to the towers with this information.
4.	Baume on acid in strong tower and acid in weak tower. M & D Method	From strong tower and weak tower	Once per hour	Acid Plant	The Acid Maker controls the strength of his acid in the towers with these test results. It tells him the concentration of his acid.
DIGESTER COOKING PROCESS					
5.	Chip Moisture M & D Method	Sample taken in Chip Bin	Once per cook	Chip Room	The cook adjusts the volume of the chips he puts in the digesters with this information.

Figure 2

3. That the frequency of certain tests be reduced. This can be accomplished in two ways: first, more efficient use of the test data (i.e., more information per test by using statistical techniques), and, second, adjusting the time between tests in accordance with the innate stability of the process.
4. That certain tests be eliminated.
5. That a program of audit testing be instituted to make the present control testing more effective.

Certain by-products accrued from the testing survey: A Manual of Testing was developed, a typical page from which is shown in Fig. 2. Composed by departments, this has proven a valuable reference for many. Responsibilities are herein formalized, which makes it useful to supervision. The lines of communication are strengthened and this tends to hasten action taken on out-of-control conditions.

TABLE I—Duplication Limits Calculated from Average Range Between Test Results Obtained on Two Samples Selected from the Process at the Same Time

Time	Sample 1	Sample 2	Range
10:30	3.92	3.87	0.05
1:05	4.03	4.00	0.03
4:20	3.92	3.92	0.00
6:30	3.92	3.95	0.03
9:05	3.97	3.92	0.05
12:20	4.00	4.00	0.00
2:30	3.90	4.00	0.10
5:05	4.00	3.92	0.08
8:20	3.97	3.97	0.00
10:30	4.03	4.00	0.03
			Total 0.37

Average Range ($\bar{R}$) = 0.037
The Maximum range permitted between the Audit and Routine Testers results on samples taken together is set at:
$D_4\bar{R} = 3.3 \times 0.037 = 0.12$
(99.7% probability level)

It was found that definition of test procedures was helpful in lessening the variation due to sampling and testing. In one case, the need for new testing equipment was demonstrated and the apparatus obtained. Changing the location of sampling points, as well as testing points, helped to make certain tests more effective for control. Management has better assurance that the basic information for judging conformance to quality standards is reliable.

The final recommendation led to establishing the formal position of an audit tester in the Control Laboratory. The audit tester is an experienced laboratory man with a sound knowledge of all the standard sampling and testing procedures. His only additional equipment is a table of statistical "duplication" limits. It is his function to make the rounds of the mill, covering a major share of the testing being done, and to run comparison samples with the tester. Whenever practical, the operators take duplicate samples throughout their shift. These are selected at random by the audit tester, who makes the test.

If the results are no farther apart than the "duplication" limits, it is considered an agreement. If the two

AUDIT TEST FORM

Test Audited _____ Department _____

Audit Tester _____ Period _____

Control Limits _____

Test Number																								
Date																								
Tester*																								
Routine Test (A)																								
Audit Test (B)																								
Diff. (A-B)																								

X = Recheck

Difference (Routine Test - Audit Test)

* Routine Testers Code: A = B = C =
D = E =

Remarks:

Figure 3

results differ by more than the statistical "duplication" limits, the audit tester imediately reviews the test procedures followed with the standard test procedure. If the reason for the difference is not readily apparent the audit tester again obtains and runs another sample with the routine tester.

The duplication limits may be calculated in a number of ways depending on the sampling and testing procedures followed. Two examples of how duplication limits may be determined are shown in Tables I-II.

It is important that the audit tester not be restricted to a definite schedule. There are two reasons: First, the routine tester should have no way of anticipating the arrival of the audit tester and, second, there should be sufficient time for the audit tester to review the sampling and testing procedure should a difference arise. The audit tester work sheet is shown in Fig. 3. This forms the basis for a monthly summary to management.

It should be noted, in connection with the establishment of the audit program, that it was done with no increase in the testing manpower. This time was made available by rescheduling the testing assignments among present personnel.

TABLE II — Duplication Limits Calculated from Variation in Test Results Obtained on a Number of Duplicate Samples by One Tester

X Test Result	X^2 Test Result
15.2	231.04
15.0	225.00
14.7	216.09
15.0	225.00
14.6	213.16
14.6	213.16
14.4	207.36
14.7	216.09
14.4	207.36
14.7	216.09
Total 147.3	2170.35
Average 14.73	

$$\text{Test Std. Devation } \sigma = \sqrt{\frac{2170.35 - \frac{(147.3)^2}{10}}{9}} = 0.263$$

The Standard Deviation for the Difference between two testers is:

$$\sigma_d = \sqrt{(0.263)^2 + (0.263)^2} = 0.37$$

The 99.7% probability limits for agreement are:

$$\pm 3\sigma_d = \pm 1.1$$

Summary

From the basic question "What is the function of testing" came the fact-finding phase of a testing survey. Perhaps its most important outcome was the initiation of an audit testing program in the mill.

For a very nominal investment in time and through a systematic approach, a sound program of audit testing may be developed. Since errors in process control often have serious consequences in off-specification product, it is essential to know that all tests are reliable. Further, relatively little is known of the interrelationships of characteristics measured early in the process with the quality of finished paper. Only through meaningful tests may these relationships be accurately determined. It appears that audit testing gives assurance of such reliability at very low cost. Its value has been demonstrated—try it.

An Application of Variance Component Analysis in the Transistor Industry

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Summary

Variance component analysis has been used extensively in many of the sciences in the assessment of variation[1, 2, 3]. It is through this analysis that the variation of observations can be broken into components associated with the various contributing elements. This method when applied to quality control analysis of a system allows the output of the system to be analyzed and the random variation of the output to be decomposed into various elements of the system. These variations are normally in terms of the variance (the square of the standard deviation) of the sources. A study of these derived variations can then serve as a basis for deciding which element should be improved to produce the maximum improvement in the system. The purpose of this article is to review an application of this technique in the electronics industry. This is only a particular application of one of the numerous experimental designs and variance component analyses which are available and is intended to serve more as an illustration of a method than as the only method.

Introduction

In view of the improper functioning of a high percentage of receivers, it was decided that a series of tests be performed to evaluate the variations of the signal generator output. These tests would have as their objective a decomposition of the signal generator output variation into the component parts associated with (1) transistor variations, (2) receiver variations, and (3) experimental error. The receivers which were subjected

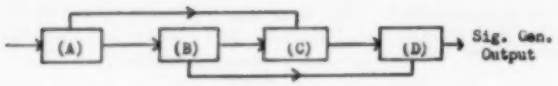

Figure 1—Schematic Diagram of Receivers Under Study

to study had in their design four different types of transistors, each of which had an influence on the signal generator output. This influence could be demonstrated clearly by observing the signal generator outputs given by leaving three of the transistors in the receiver and replacing the fourth transistor with different transistors of the same type. A careful study of the system indicated that there was very little interaction between the transistors relative to the signal generator output and that the effects of the transistors, on this output, could be considered additive. These decisions were such that the assumptions in experimental design and variance component analysis theory were satisfied and the study could be effectively pursued.

Basic Concepts

Schematically, the receivers under study are represented in Fig. 1, where A is a transistor of one type, B a transisitor of another type, etc. Each of these transistors, being of different types, is from a different statistical population. Since the effects on output of the various transistors are additive and do not interact, it can be stated mathematically that a randomly selected transisitor of each type inserted in a randomly selected receiver will produce an output of the following type: where

$$Y = m + r + a + b + c + d + e$$

Y — is the signal generator output

m — is a nominal generator output

r — is a random variable contribution of a particular receiver of the receiver population.

a — is a random variable contribution of a particular A transistor of the population of A transistors.

b — is a random variable contribution of a particular B transistor of the population of B transistors.

c — is a random variable contribution of a particular C transisitor of the population of C transistors.

d — is a random variable contribution of a particular D transistor of the population of D transistors.

e — is a random variable contribution of the system and is a function of numerous uncontrollable factors such as recording technique, operator error, system characteristics, environmental conditions, etc.

From a careful study of this model and the desired results, it was noted that an experiment which used a Graeco-Latin square arrangement of transistor combinations in a completely randomized design for each receiver and a random selection of receivers would be appropriate. This design has the advantages of eliminating worthless information on non-existent interaction and of presenting a balance of information on the different quantities being investigated. In view of the time and costs allocated for this study, it was decided that the Graeco-Latin squares should be of side 5 and that 11 receivers could be used in the study.

TABLE I—Transistor Arrangement

	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}
B_{11}	C_{11} D_{11}	C_{12} D_{12}	C_{13} D_{13}	C_{14} D_{14}	C_{15} D_{15}
B_{12}	C_{13} D_{12}	C_{14} D_{13}	C_{15} D_{14}	C_{11} D_{15}	C_{12} D_{11}
B_{13}	C_{15} D_{13}	C_{11} D_{14}	C_{12} D_{15}	C_{13} D_{11}	C_{14} D_{12}
B_{14}	C_{12} D_{14}	C_{13} D_{15}	C_{14} D_{11}	C_{15} D_{12}	C_{11} D_{13}
B_{15}	C_{14} D_{15}	C_{15} D_{11}	C_{11} D_{12}	C_{12} D_{13}	C_{13} D_{14}

Experimental Design

The mathematical model for this completely randomized Graeco-Latin square design is:

$$Y_{ijkem} = m + r_i + a_{j(i)} + b_{k(i)} + c_{e(i)} + d_{m(i)} + e_{ijkem}$$

where i takes on the values 1, 2,. . . . , 11 and j, k, e, and m take on the values 1, 2, 3, 4, and 5 according to the Graeco-Latin square designations; the other terms are as before except that the subscripts now indicate which receiver is being considered. To illustrate this model more clearly, the experimental arrangement of the transistors for the first receiver is given in Table I. To produce this receiver arrangement, five transistors are selected at random from each of the four transistor populations. The A transistors are labeled A_{11}, A_{12}, A_{13}, A_{14}, and A_{15}; the B transistors B_{11}, B_{12}, B_{13}, B_{14}, and B_{15}; the C transistors C_{11}, C_{12}, C_{13}, C_{14}, and C_{15}; and the D transistors D_{11}, D_{12}, D_{13}, D_{14}, and D_{15}; the first subscript indicates the receiver the transistors will be used in and the second subscript identifies the transistor. The test combinations are then given according to Table I.

Thus, one transistor test combination is given by transistors A_{11}, B_{11}, C_{11}, and D_{11}, a second is A_{11}, B_{12}, C_{12}, and D_{12}, etc. Having determined the twenty-five combinations for the first receiver from Table I, the twenty-five combinations were then randomized to obtain testing order. After randomization, the twenty-five combinations were then tested and the signal generator output recorded for analysis. The recorded data are given in Table II.

TABLE II—Signal Generator Output—KUV

Receivers	1	2	3	4	5	6	7	8	9	10	11
Transistors											
A-1B-1C-1D-1	35	34	29	18	20	31	23	13	21	18	29
A-1B-2C-2D-2	32	21	36	17	18	35	18	16	22	10	35
A-1B-3C-3D-3	35	29	24	21	21	27	29	21	18	13	30
A-1B-4C-4D-4	59	21	46	23	20	34	18	18	24	20	51
A-1B-5C-5D-5	72	19	29	13	23	37	33	23	19	10	29
A-2B-1C-3D-2	44	21	23	23	27	30	35	18	17	7	35
A-2B-2C-4D-3	67	23	35	30	19	31	23	16	18	25	65
A-2B-3C-5D-4	40	20	42	12	20	32	25	18	20	13	40
A-2B-4C-1D-5	62	28	32	23	28	25	36	17	14	16	38
A-2B-5C-2D-1	29	20	24	13	20	22	18	14	22	19	40
A-3B-1C-5D-3	44	20	32	17	22	37	39	14	17	28	34
A-3B-2C-1D-4	31	38	42	21	20	32	30	17	14	26	48
A-3B-3C-2D-5	42	21	28	14	3	31	24	14	20	15	28
A-3B-4C-3D-1	39	33	22	21	24	25	25	13	18	12	38
A-3B-5C-4D-2	81	17	24	23	24	36	23	18	20	13	51
A-4B-1C-2D-4	22	23	38	13	21	29	20	14	23	21	34
A-4B-2C-3D-5	52	35	25	21	28	28	32	22	14	13	36
A-4B-3C-4D-1	55	25	24	18	21	27	14	17	24	23	45
A-4B-4C-5D-2	51	22	26	15	20	28	25	16	20	9	37
A-4B-5C-1D-3	29	32	26	20	18	22	35	20	15	25	37
A-5B-1C-4D-5	150	21	29	22	37	38	28	16	21	14	34
A-5B-2C-5D-1	46	29	22	13	21	36	21	14	21	13	39
A-5B-3C-1D-2	36	32	20	18	25	32	30	17	20	14	31
A-5B-4C-2D-3	28	23	23	18	22	27	22	12	21	23	33
A-5B-5C-3D-4	29	28	24	16	25	32	34	24	17	13	47

Theory of Analysis

The analysis of the data was accomplished through the standard analysis of variance and component analysis techniques. The formulas summarizing the analysis of variance techniques are given in Table III. Special notations have been used in these formulas as follows: the lower subscripts on the summation symbols indicate summation over all possible values of the index for the

summed quantity; a dot as a subscript of a symbol indicates summation over all possible values of that subscript for the summed quantity. This notation eliminates the use of Kronecker deltas which are sometimes found in the formula and also permits simplified algebraic manipulation.

As in the conventional analysis of variance, the transistor and receiver mean squares can be compared with the system error mean square and an F test applied for significance. However, in this case the interest is not in the significance, and the test will have little if any bearing on the estimation of the variance components. That is, it has already been decided that the differences

TABLE III—Analysis of Variance

Source of Variation	Deg. of Freedom	Sums of Squares	Mean Squares
			Sum of Squares
Total	274	$\sum_{ijkem} Y^2_{ijkem} - (1/275)\, Y^2_{\cdots\cdot}$	Deg. of Freedom
Receivers	10	$(1/25) \sum_{i} Y^2_{i\cdots\cdot} - (1/275)\, Y^2_{\cdots\cdot}$	"
"A" Transistors	44	$(1/5) \sum_{ij} Y^2_{ij\cdots} - (1/25) \sum_{i} Y_{i}{}^2_{\cdots}$	"
"B" Transistors	44	$(1/5) \sum_{ik} Y^2_{i\cdot k\cdot\cdot} - (1/25) \sum_{i} Y_{i}{}^2_{\cdots}$	"
"C" Transistors	44	$(1/5) \sum_{ie} Y^2_{i\cdot\cdot e\cdot} - (1/25) \sum_{i} Y_{i}{}^2_{\cdots}$	"
"D" Transistors	44	$(1/5) \sum_{im} Y^2_{i\cdot\cdot\cdot m} - (1/25) \sum_{i} Y_{i}{}^2_{\cdots}$	"
System Error	88	Total Sum of Squares Minus all other SS	"

of the A, B, C, D, transistors and receivers exist and are random. Under this assumption, and with the objective of variance component analysis, the remaining theoretical considerations are in the determination of the expected values of the mean squares. The expected values of the mean squares are the average values that would be obtained if the experiment were repeated many times and the calculated values for each source of variation in Table III averaged over all the experiments. Thus, the expected values of the mean squares are the values of which the particular calculated mean squares are estimates. These values have been derived and are presented in Table IV. These expected values are in terms of variances of the various sources of variation, σ^2 denoting variance and the subscript denoting the source. The derivation of these values is reasonably straight forward and will not be treated in detail here. Appendix A gives sample derivations, the method of derivation being the same in other cases.

Having formulas to calculate mean squares and formulas for their expected values, the two sets of quantities can be equated to produce a set of six equations in terms of the six unknowns σ_r^2, σ_a^2, σ_b^2, σ_c^2, σ_d^2, and σ^2_{se}. From the model, it is easily established that the variance of a randomly selected signal generator output is the sum of the variance components above. Thus: $\sigma_Y^2 = \sigma_r^2 + \sigma_a^2 + \sigma_b^2 + \sigma_c^2 + \sigma_d^2 + \sigma^2_{se}$.

The percentage of variation associated with each of the different sources are one-hundred times σ_r^2/σ_Y^2, σ_a^2/σ_Y^2, σ_b^2/σ_Y^2, σ_c^2/σ_Y^2, σ_d^2/σ_Y^2, and σ^2_{se}/σ_Y^2. These percentages are the key to the source of variation which is responsible for most of the variation in the signal generator output.

TABLE IV—Variance Components

Source of Variation	Deg. of Freedom	Expected Mean Squares
Total	274	
Receivers	10	$25\sigma_r^2 + 5\sigma_a^2 + 5\sigma_b^2 + 5\sigma_c^2 + 5\sigma_d^2 + \sigma^2_{se}$
"A" Transistors	44	$\sigma^2_{se} + 5\sigma_a^2$
"B" Transistors	44	$\sigma^2_{se} + 5\sigma_b^2$
"C" Transistors	44	$\sigma^2_{se} + 5\sigma_c^2$
"D" Transistors	44	$\sigma^2_{se} + 5\sigma_d^2$
System Error	88	σ^2_{se}

Application

Applying the formulas of Table III to the data in Table II gives the data in Table V.

Equating the mean squares in Table V to the expected mean squares in Table IV and solving the resulting system of equations gives the variance estimates $\sigma_r^2 = 82.15$; $\sigma_a^2 = 3.57$; $\sigma_b^2 = 4.78$; $\sigma_c^2 = 47.99$; $\sigma_d^2 = 28.95$; and $\sigma^2_{se} = 21.62$. Combining these values to obtain the variance of a randomly selected output gives $\sigma_Y^2 = 189.06$. The percentage of the variation associated with each source is then given in Table VI.

From these results, it is apparent that the major portion of the output variation is due to variation between and within the receivers. Thus, if variation reductions as large as 50 percent are required, the basic receiver must be improved. If improvement is derived through transistor study and redesign then transistors C and D are the ones which will contribute the most. The contributions to the output variation of transistors A and B are negligible and offer very little as improvement possibilities.

Conclusions

In this article a successful application of variance component analysis in electronics has been described. Undoubtedly in this area there are many other applications of this useful concept which should be under-

TABLE V—Analysis of Variance Table

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square
Total	274	49,492.65	
Receivers	10	25,019.13	2,501.91
A Transistors in Receivers	44	1,736.37	39.46
B "	44	2,002.45	45.51
C "	44	11,510.61	261.60
D "	44	7,321.29	166.39
System Error	88	1,902.80	21.62

TABLE VI—Percentage Variations

Variation Due To	% of Total Variation
A Transistors	1.9
B Transistors	2.5
C Transistors	25.4
D Transistors	15.3
All Transistors (A, B, C, and D)	45.1
System Error	11.4
Receivers	43.5
System Error and Receivers	54.9
Total (All Sources)	100

taken. Not only should these applications be considered in the study of effects, but under other models the possibility of using control charts on the variance components should be investigated. The authors are currently exploring this possibility since the successful manufacture of many electronic devices depends strongly on the variability of components which are used in those devices and the control of this variation has been a long standing problem.

Acknowledgments

The authors take this opportunity to express their appreciation to Mr. T. E. Smith, Mr. James Nygaard, and Mrs. Peggy Moranz. Messrs. Smith and Nygaard contributed significantly in the preparation of this article by seeing that the experiment was conducted in a completely scientific manner and by their ideas and interpretation of the results as the work progressed. Mrs. Moranz was instrumental in preparing the manuscript for publication.

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Appendix A—Derivation of Expected Mean Squares

Type A Transistors Within Receivers

Consider

$$I = 1/5 \sum_{ij} Y^2_{ij\ldots} - 1/25 \sum_{i} Y^2_{i\ldots.} \quad (1)$$

I can be written in the form

$$I = 5 \sum_{ij} (Y_{ij\ldots}/5 - Y_{i\ldots.}/25)^2 \quad (2)$$

From the model and the notation

$$Y_{ij\ldots}/5 = m + r_i + a_{j(i)} + b_{.(i)}/5 + c_{.(i)}/5 + d_{.(i)}/5 + e_{ij\ldots}/5 \quad (3)$$

and

$$Y_{i\ldots.}/25 = m + r_i + a_{.(i)}/5 + b_{.(i)}/5 + c_{.(i)}/5 + d_{.(i)}\,5 + e_{i\ldots.}/25 \quad (4)$$

Substituting (3) and (4) into (2) and simplifying gives

$$I = 5 \sum_{ij} (a_{j(i)} - a_{.(i)}/5 + e_{ij\ldots}/5 - e_{i\ldots.}/25)^2 \quad (5)$$

Taking the expected values yields

$$E(I) = (5)(11)(5E)(a_{j(i)} - a_{.(i)}/5 + e_{ij\ldots}/5 - e_{i\ldots}/25)^2 \quad (6)$$

Expanding the right-hand side of (6) and using the independence of $a_{j(i)}$ and e_{ijkem}

$$E(I) = 275E\,(a_{j(i)} - a_{.(i)}/5)^2 + 275E\,(e_{ij\ldots}/5 - e_{i\ldots.}/25)^2 \quad (7)$$

Expanding the terms in parenthesis and taking their expected value gives

$$E(I) = 275\,(16/25 + 4/25)\,\sigma_a^2 + 275\,[(16)(5)\,625 + 20/625]\,\sigma^2_{se} \quad (8)$$

or

$$E(I) = 220\,\sigma_a^2 + 44\,\sigma^2_{se} \quad (9)$$

Since

$$E(I/44) = E(\text{Mean Square for A}) = E(I)/44 \quad (10)$$

$$E(\text{Mean Square for A}) = 5\sigma_a^2 + \sigma^2_{se} \quad (11)$$

Receivers

Consider

$$J = \sum_{i} Y^2_{i\ldots.}/25 - Y^2_{\ldots.}/275 \quad (1)$$

J can be expressed in the form

$$J = 25 \sum_{i} (Y_{i\ldots.}/25 - Y_{\ldots.}/275)^2 \quad (2)$$

From the model and the notation

$$Y_{i\ldots.}/25 = m + r_i + a_{.(i)}/5 + b_{.(i)}/5 + c_{.(i)}/5 + d_{.(i)}/5 + e_{i\ldots.}/25 \quad (3)$$

and

$$Y_{\ldots.}/275 = m + r_{.}/11 + a_{..}/55 + b_{..}/55 + c_{..}/55 + d_{..}/55 + e_{\ldots.}/275 \quad (4)$$

Substituting (3) and (4) into (2) and simplifying gives

$$J = 25 \sum_{i} (r_i - r_{.}/11 + a_{.(i)}/5 - a_{..}/55 + b_{.(i)}/5 - b_{..}/55 + c_{.(i)}/5 - c_{..}/55 + d_{.(i)}/5 - d_{..}/55 + e_{i\ldots.}/25 - e_{\ldots.}/275)^2 \quad (5)$$

Taking the expected value of (5) and using the distributive law

$$E(J) = 25 \sum_{i} E\,(r_i - r_{.}/11 + a_{.(i)}/5 - a_{..}/55 + b_{.(i)}/5 - b_{..}/55 + c_{.(i)}/5 - c_{..}/55 + d_{.(i)}/5 - d_{..}/55 + e_{i\ldots.}/25 - e_{\ldots.}/275)^2 \quad (6)$$

$$E(J) = (25)(11)\,E\,(r_i - r_{.}/11 + a_{.(i)}/5 - a_{..}/55 + b_{.(i)}/5 - b_{..}/55 + c_{.(i)}/5 - c_{..}/55 + d_{.(i)}/5 - d_{..}/55 + e_{i\ldots.}/25 - e_{\ldots.}/275)^2 \quad (7)$$

Expanding the terms in parenthesis gives

$$E(J) = 275E(r_i - r_{.}/11)^2 + 275E(a_{.(i)}/5 - a_{..}/55)^2 + 275E(b_{.(i)}/5 - b_{..}/55)^2 + 275E(c_{.(i)}/5 - c_{..}/55)^2 + 275E(d_{.(i)}/5 - d_{..}/55)^2 + 275E(e_{i\ldots.}/25 - e_{\ldots.}/275)^2 \quad (8)$$

Further expanding of the terms in parenthesis and taking their expected values gives

$$E(J) = 275(100/121 + 10\ 121)\sigma_r^2 + 275[(10)^2\ 5/(55)^2 + 50/(55)^2]\sigma_a^2 + \ldots + 275\ \{[(10)^2\ 25 + 250]/(275)^2\}\sigma^2_{se} \quad (9)$$

$$= 250\ \sigma_r^2 + 50\ \sigma_a^2 + 50\ \sigma_b^2 + 50\ \sigma_c^2 + 50\ \sigma_d^2 + 10\ \sigma^2_{se} \quad (10)$$

Since

$$E(J/10) = E(\text{Mean Square for Receivers}) = E(J)/10 \quad (11)$$

Equations (10) and (11) yield

$$E(\text{Mean Square for Receivers}) = 25\sigma_r^2 + 5\sigma_a^2 + 5\sigma_b^2 + 5\sigma_c^2 + 5\sigma_d^2 + \sigma^2_{se} \quad (12)$$

The Mechanical Lot Plot Templet

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Pratt & Whitney Aircraft Co., Inc., East Hartford, Conn.

The protection advantages that variables-type sampling has over attribute-type sampling have long been apparent. However, the calculation time involved for variables-type sampling and the need for trained personnel to perform those calculations generally have prevented the widespread use of variables-type sampling plans. The Mechanical Lot Plot Templet was developed in order to eliminate these objections from one of the most popular of the variables-type sampling plans used for lot acceptance—"The Hamilton Standard Lot Plot Method of Acceptance Sampling by Variables."[1]

In the lot plot procedure, fifty pieces are selected at random from an incoming lot, and a point is plotted on a distribution chart to represent the variable gaging result of each of the pieces. The upper and lower 3-σ control limits of the plotted *distribution* are calculated; these limits generally represent with acceptable accuracy the limits for the complete lot. The Mechanical Lot Plot Templet determines these limits without the need of mathematical calculations and trained personnel.

These advantages are accomplished by using transparent templet belts on which the "reasonable" frequency cell control limits of predetermined half-distributions have been transcribed. The 3-σ limit on the templet which the corresponding side of the sample's frequency distribution best fits is considered the 3-σ limit for that side of the lot distribution from which the random sample is taken. This technique is an adaptation with modifications to the principle presented by D. A. Hill[2] at the Aircraft Quality Control Conference in 1953.

The Mechanical Lot-Plot Templet, working with half-distributions only, has two continuous templet belts, and each belt has 11 half-distribution templets (from three to eight cells in half-cell intervals) transcribed on it. The matching of the half-distributions of these belts quickly produces a total of 121 (11 $\times$ 11) possible 50-piece distributions, each with a different degree of skewness. Most lot plot charts, no matter what the skewness, can therefore be easily calculated with the Mechanical Lot Plot Templet.

The procedure for the use of the machine is simple and non-skilled people can be trained in a matter of

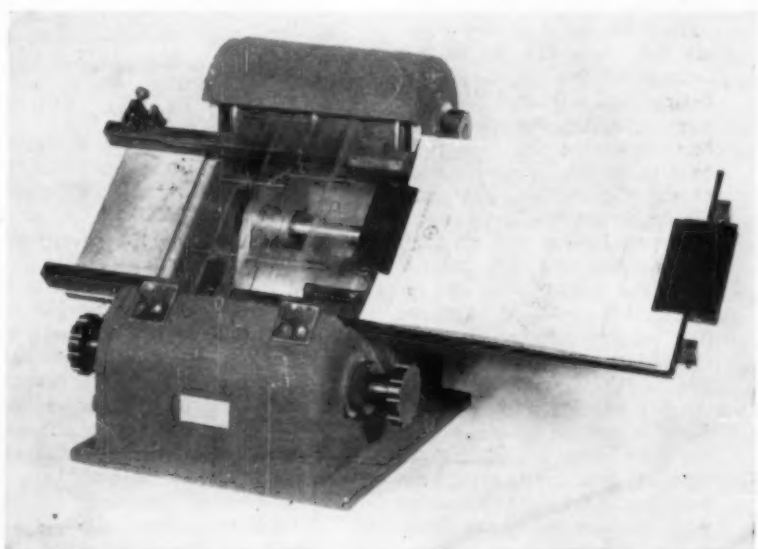

Figure 1—Method of Installing Chart in Mechanical Lot Plot Templet

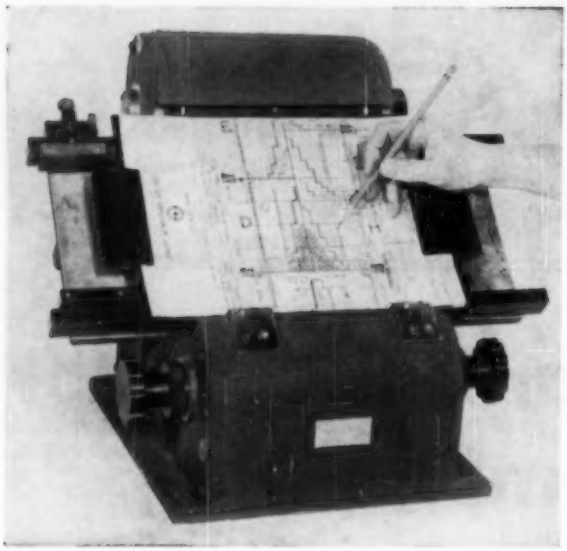

Figure 2—Method of Transcribing Lot Limits on Mechanical Lot Plot Templet

minutes. The procedure is as follows:

1. Slide the feeder plate to the right and attach the Lot Plot Chart (see Fig. 1).
2. Determine the "midpoint line" of the distribution. Select the value cell on the distribution chart that divides the chart distribution into two approximately equal numerical halves. If this selected value cell is also the mode cell (largest frequency of any value cell) and the distribution is a unimodal distribution, consider the midpoint of the value cell to be the "midpoint line" of the distribution. If the selected value cell is not the mode cell of a unimodal distribution, consider the selected cell's value cell limit line nearest the mode cell, to be the "mid-point line" of the distribution. On bi-modal distributions, consider the value cell line separating the two mode cells to be the "midpoint line" of the distribution. Note that the "midpoint line" is always a cell limit line or the midpoint between two cell limit lines.
3. Slide the feeder plate to the left until the selected "midpoint line" of the distribution coincides with the templet center line which is located between the two templet belts.
4. Select a templet for one side of the distribution by turning the templet belt until, when the base line of the templet lines up with the base line of the distribution, the uppermost frequency cell of each individual value cell of that half of the chart distribution falls between the red line and blue line of the selected templet.
5. Repeat operation 4 for opposite half of distribution.
6. Adjust either or both belts or the selected midpoint line so that the combination of selected templets shall be the two that the cell distribution fits best.
7. Draw lot limit lines on the chart, by using the cutaway slot in the belt at the lower frequency end of each templet distribution. The inner edge of the slot coincides with the 3-σ limit of the distribution involved and is therefore used as a guide for drawing the lot limit line. Mark on each side of the chart the letter that represents the templet used on that half of the distribution (See Fig. 2).
8. Remove the chart from the machine and draw specification lines. If the lot limit is outside of specification, consult the reference chart for the percent outside of specification (See Fig. 3).

The templets were made up in the following manner: one-sided distributions from three to eight horizontal cells (class intervals) were selected in half-cell intervals and the theoretical cell frequency was determined for each horizontal cell of each 25 piece one-sided distribution. The cell frequency was transformed into $\bar{p}$ for each individual class interval cell by dividing the theoretical cell frequency for the cell by the sample size. The upper and lower control limits of each cell were determined by the formulas

$$UCL = \bar{p} + t\sqrt{\frac{(\bar{p})(1-\bar{p})}{n}}$$

$$LCL = \bar{p} - t\sqrt{\frac{(\bar{p})(1-\bar{p})}{n}}$$

where

$\bar{p}$ = average percent frequency of individual cell
t = selected confidence multipler
n = sample size (See Fig. 4)

These p limits were multiplied by the sample size to determine the cell frequency control limits that are in-

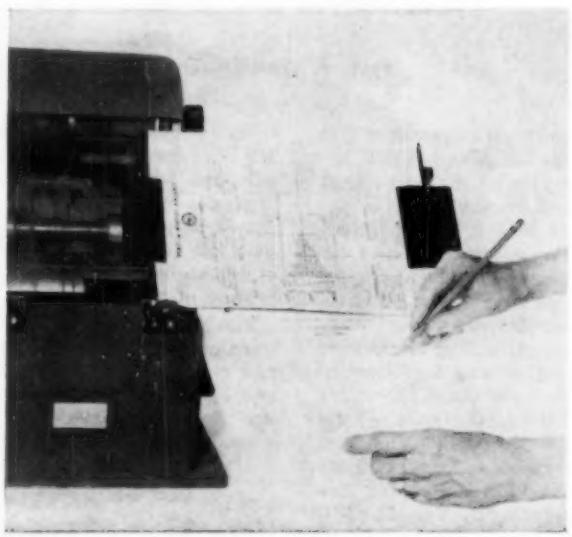

Figure 3—Method for Determining the Percent of Lot Outside Specifications with Mechanical Lot Plot Templet

scribed on the templets. The upper control limits of the separate class interval cells were connected and inscribed on the transparent templet belt in red. The lower control limits of the separate class interval cells were connected and inscribed on the transparent templet belt in blue. The selected confidence interval (t) was chosen separately for each limit so that the particular limit involved would, when transcribed on the templet, coincide with a frequency cell line. The selected intervals were such that the actual confidence limits varied between 85 and 99 percent.

Each continuous belt contains eleven half-templet distributions, with the frequency distribution outlines on one belt the mirror image of those on the other belt. The 121 possible templet combinations make the machine adaptable to most 50-piece lot plot charts. The exceptions are when one side of the distribution involves more than 30 items or less than 20 items or when strays are encountered.

The Mechanical Lot Plot Templet method holds the following advantages over the conventional mathematical calculation method:

1. *Speed*—No lengthy mathematical calculations are necessary. Time Studies show an average saving of three minutes per lot plot chart.
2. *Elimination of Mathematical Errors*—The elimination of mathematical calculations eliminates the possibility of mathematical errors.
3. *Shortening of Training Time*—Since unskilled personnel can determine lot limits in a short time by using this method, trained analysts are not required. The feature is especially attractive when starting a lot plot program and competent lot plot analysts are not available.
4. *Facility in Supervision*—Supervision can determine whether transcribed lot limits are correct simply by glancing at the Mechanical Templet. This eliminates time consuming checking of mathematical calculations.
5. *Normalcy of each Sample Distribution Checked*—A check similar to chi-square check for normalcy is automatically made for each distribution. If the sample distribution fits a templet, it is a possible "normal" distribution.

The accuracy of the templet method has not definitely been mathematically calculated. A comparison of the known distribution results obtained by using the mechanical templet method with the results obtained by using the conventionally accepted methods of calculating lot plot charts indicates that only a very small variation between the methods exists. This variation can be considered to be minor when compared to the overall variation (due to sampling, etc.) between different lot plots from the same universe.

Figure 5 is a typical example of such a comparison. Information for 50 lot plot charts of 50 pieces each was drawn from a normal bowl of 500 chips. Chips were drawn one at a time from the bowl and recorded. After drawing five chips, all chips were returned to the bowl and remixed. This distribution of the chips had a mean of 20 and a standard deviation of 2.55. Each lot plot chart, determined in this manner, was calculated by each of three methods: (1) True method, using ΣFX and ΣFX^2, (2) Range method, using a sample of five and (3) Mechanical Lot Plot Templet. The mechanical lot plot templet operator had no previous lot plot training, did not know of the expected results, and operated the mechanical lot plot templet only according to the directions given here. It should be noted that the individual points plotted in Fig. 5 are themselves the upper control limit results of the 50 individual lot plot charts drawn from the known universe. The theoretical average of each of the curves should therefore be the theoretical UCL of the sample lot plot or 27.65 ($\bar{X}$ of universe is 20, σ of universe is 2.55. $UCL = \bar{X} + 3\sigma = 20 + 7.65 = 27.65$). A plot of the lower control limits shows of course, similar distributions. Examination of Fig. 5 shows that the spread due to sampling chance and other such variables for each method is much greater than

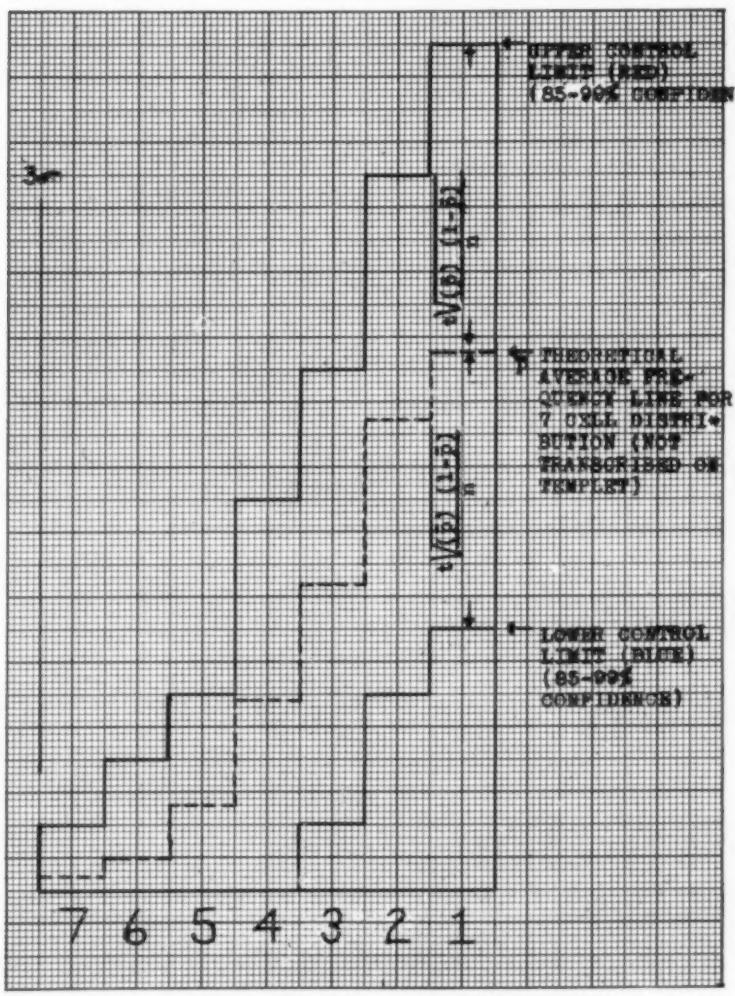
UPPER CONTROL LIMIT (RED) (85-99% CONFIDENCE
3
THEORETICAL AVERAGE FREQUENCY LINE FOR 7 CELL DISTRIBUTION (NOT TRANSCRIBED ON TEMPLET)
LOWER CONTROL LIMIT (BLUE) (85-99% CONFIDENCE)
7 6 5 4 3 2 1

Figure 4—Method Used for Determining Templet Lines

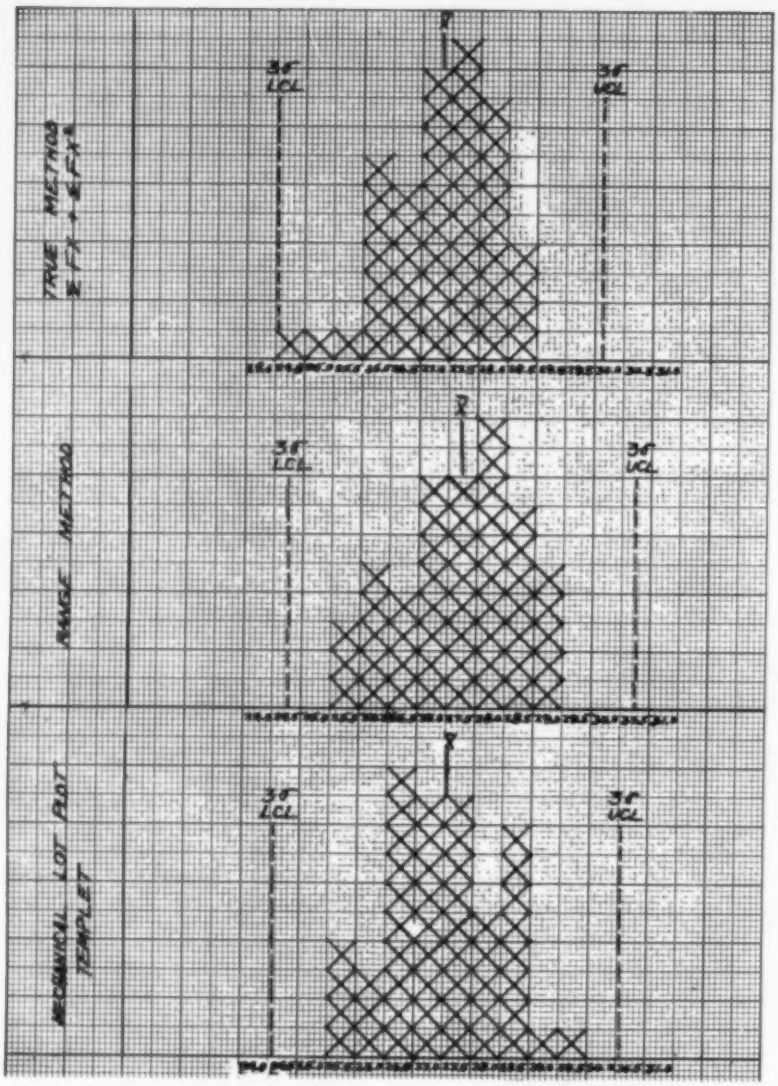

Figure 5—Histograms with Three Different Methods used to Calculate Upper Control Limits of Fifty Individual Lot Plot Charts Taken from a Known Distribution ($\bar{x} = 20$, $\sigma = 2.55$)

any small difference that might exist between methods of calculation. It should be noted, however, that at times there is a difference of as much as two cells between methods on the UCL calculation of an individual lot plot. However, when such differences exist, there is no trend for any one method to consistently produce the lowest or the highest result. This difference, however, points out that for expected protection it is necessary to use the same method constantly in calculating limits and not to vary the method between charts in order to find the most favorable one.

The mechanical lot plot templet is not commercially available. Two actual models have been made; one a crude prototype model, and the other the finished model shown in this article, which is much more luxurious than is needed and much too expensive for commercial application except in high volume areas.

In summary, the mechanical (lot plot) templet is a method of achieving the benefits of variable sampling, without the disadvantages of time consuming mathematical calculations and the necessity of highly trained personnel.

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Air Materiel Command

begins civilian engineer recruitment program

The Air Materiel Command has underway a program to recruit 31 civilian engineers for work in quality control at ballistic missiles plants and test facilities.

Plans are still being formulated to train at least ten Air Force engineer officers to take part in that program along with the civilians.

The Air Force practice of "flight test and fix" in connection with the acceptance of aircraft for operational use is not valid in relation to missiles. Under present practice, test personnel, by flying a new airplane, report any deficiencies or weakness in performance. By a series of continuous flight and service tests, each new aircraft finally enters the Air Force inventory as a product of the

best possible design and manufacturing methods.

But now, as the Air Force swings whole-heartedly into the missile age, the old practice is not possible. While the manned airplane lends itself to "flight test and fix," the incredibly expensive ballistic and guided missiles fly once and that is all. Considering the vital mission each missile will have to perform in the event of war, this nation cannot afford to have an ICBM, for example, fail on its one and only flight.

The Air Materiel Command, charged with the quality control responsibility for the Air Force, in addition to procurement, maintenance and supply of all items used around the world, has developed a program to use professional engineers assigned to the quality control task at ballistic missile installations.

"We realize this is not a startling development: using graduate engineers in quality control work," said Colonel J. G. Schneider, AMC's chief of quality control. "But this is the first time we have written the requirement that professional engineers *must* be used in certain activities in the Air Force quality control program."

"The primary function of Quality Control is to assure compliance with specified technical requirements," he continued. "The requirements for modern weapon systems are stated in complex scientific and mathematical terminology. If the Air Force quality control representative (AFQCR) is to adequately discharge his responsibilities for quality and reliability assurance, it becomes quite obvious that he must be able to comprehend this technical terminology and intelligently communicate with all personnel working in this engineering enviroment."

In August, 1957, Lt. General William F. McKee, acting in place of the AMC Commander, General E. W. Rawlings, notified all Air Materiel Areas of the plans underway to recruit 31 electronic, power plant, and chemical engineers for assignment to ballistic missile facilities.

The starting salary established for these positions is $10,065, because the level of responsibility requires that fully qualified engineers be brought into the program. Recruiting is taking place from within and from outside the civil service system.

The quality control people at AMC have been pushing for the Civil Service Commission to establish a new series of jobs to include the pro-

(Continued on page 22)

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One of the major spokes is Commonwealth Avenue. Beginning in Newton it approximately follows the Charles River as it winds its way through Cambridge and Boston. Where the river runs into Boston harbor, it has been dammed to form an unusually beautiful basin, bordered on the Boston side by the scenic parks and lagoons of Storrow Drive.

Near the lower end of the basin is a permanent band shell where members of the Boston Symphony Orchestra play summer concerts. Directly beyond the shell to the right, Beacon street leads past the Public Gardens with its swan boats, miniature suspension bridges and rare flowers. This famous thoroughfare continues on up the hill along historic Boston Common with its English elms, Frog Pond, monuments and ferocious squirrels to the noble Bulfinch-designed State House with its gold-leaf dome.

The literary flowering of New England of the last century was centered in Boston and Beacon Hill. The brick houses of Louisberg Square and those with lavender panes of glass on Beacon street were silent witnesses as Holmes, Longfellow, Whittier, Thoreau, Emerson and Lowell walked by on their way to their publishers, Tichnor and Fields, above the Old Corner Bookstore. In this period, as well as during the Civil War, Boston's Puritan heritage produced notable reformers who had a marked influence on education, penology and child welfare. In Boston philanthropy was a profession; wealth had its duties rather than its privileges.

Down from Beacon Hill is the Massachusetts General Hospital where anesthesia was first used. In addition Boston claims a number of equally outstanding medical and diagnostic centers, including the world-renowned Boston Children's Medical Center.

Across the river in nearby Cambridge are Harvard, the oldest university in the United States, and Radcliff, one of the leading women's colleges. Along the river are the domed buildings of the Massachusetts Institute of Technology. Boston University, Boston College, Tufts, Wellesley, Northeastern and Simmons are a few of the other institutions of higher learning which cluster around Metropolitan Boston.

Today in downtown Boston, you will find the heart of investment banking in the United States. Along the waterfront the largest fishing industry in the country is operating in full swing, but in far different craft than the famous clipper ships of McKay which made Boston one of the wealthiest cities of the last century. At the Charleston Navy Yard across the river is the frigate Constitution — famous for her exploits in the War of 1812 which won her the nickname, "Old Ironsides." And in East Boston, only a few minutes drive from the hotels is Logan International Airport with the longest runway in the East.

At the convention you will be making your headquarters at the Statler or Sheraton-Plaza hotels, both of which are within a few blocks of the Charles River, the Public Gardens, the State House and many other historic spots. When you are with us in May, we hope you will be able to plan a few extra days to explore the literally hundreds of places, both old and new, in a city steeped in the traditions of the past, but meeting the challenge of the future.

ASQC Convention Exposition Chart

12TH ANNUAL CONVENTION AND EXPOSITION
HOTEL STATLER • BOSTON, MASSACHUSETTS
MAY 26 - 28, 1958

SCHEDULE OF EVENTS

Headquarters Hotels, Statler & Sheraton-Plaza
Technical Sessions, Statler & Sheraton-Plaza
Exposition, Hotel Statler Ballroom

SUNDAY—MAY 25

4:00-9:00 pm	Boston Section Open House: Georgian Room of Hotel Statler. A special registration desk will be open for both Advance and Current registrations.

MONDAY—MAY 26

8:30 am	Registration: Mezzanine of Hotel Statler only.
8:30 am-6:00 pm	Exhibits: Hotel Statler Ballroom only.
10:30 am-11:30 am	Technical Sessions
12:30 pm	Luncheon: Ballroom of Sheraton-Plaza Hotel. Guest speaker: Hon. Perkins McGuire, Assistant Secretary of Defense.
2:00 pm	*Plant trips: The Dewey & Almy Chemical Co., Keystone Mfg. Co., Gillette Safety Razor Co.
3:00 pm-4:00 pm	Technical Sessions
4:15 pm	Annual Meeting, ASQC: Bay State Room, Hotel Statler.
9:00 pm	†Social Evening: Ballroom of Sheraton-Plaza Hotel.

TUESDAY—MAY 27

8:30 am	Registration: Mezzanine of Hotel Statler only.
8:30 am-6:00 pm	Exhibits: Hotel Statler Ballroom.
9:00 am-10:00 am	Technical Sessions
10:30 am-11:30 am	Technical Sessions
12:30 pm	Luncheon: Ballroom of Sheraton-Plaza Hotel. Guest speaker: Erwin D. Canham, Editor of *The Christian Science Monitor*.
2:00 pm	*Plant trips: Arthur D. Little Co., Gillette Safety Razor Co., Western Electric Co., Walter Baker Chocolate Corp.
3:00 pm-4:00 pm	Technical Sessions
6:30 pm	Annual Banquet: Ballroom of Sheraton-Plaza Hotel.

WEDNESDAY—MAY 28

8:30 am	Registration: Mezzanine of Hotel Statler only.
8:30 am-3:00 pm	Exhibits: Hotel Statler Ballroom.
9:00 am-10:00 am	Technical Sessions
10:30 am-11:30 am	Technical Sessions
12:30 pm	Luncheon: Ballroom of Sheraton-Plaza Hotel.
2:30 pm- 3:30 pm	Technical Sessions

LADIES' PROGRAM

Ladies' Headquarters during the entire Convention: Room 436, Hotel Statler.

MONDAY—MAY 26

9:00 am	Hospitality Hour: Terrace Room, Hotel Statler. Feature: An Introduction to Historic Boston.
1:45 pm	‡Special tour of Historic Boston.
9:00 pm	†Social Evening: Ballroom of Sheraton-Plaza Hotel.

TUESDAY—MAY 27

9:00 am	Hospitality Hour: Terrace Room, Hotel Statler.
12:15 pm	Luncheon: Union Oyster House. The balance of the afternoon has been left free. A generous list of optional activities will be made available.
6:30 pm	Annual Banquet: Ballroom of Sheraton-Plaza Hotel. Separate Registration Fee may be paid in advance or at Convention.
8:00 pm	†Pops Concert Tickets available for those not wishing to attend the Annual Banquet.

WEDNESDAY—MAY 28

9:00 am	Hospitality Hour: Terrace Room, Hotel Statler. Feature: Flower Arrangements.
11:00 am	††‡An optional trip has been arranged to Salem and the North Shore with luncheon at the famous Seven Gables Inn. †Numerous other optional trips will be available.

*Special nominal registration fee to help defray the costs of this activity. Tickets available in Registration area only. Buses leave from Sheraton-Plaza Hotel.
†Optional extra cost item, not included in registration fee.
‡Buses leave from Hotel Statler.

(Continued from page 19)
fessional requirements now needed. Pending such action, they have written new job descriptions around already standard job titles. It is expected that when all the armed services agree on the proper requirements, the Civil Service Commission will come up with the new series.

In addition to the civilian positions called for under the new program, AMC is seeking ten AF officers, already possessing engineering degrees, to take further training in order to work into quality control. The graduate training would consist of a years work in a civilian college leading to a master's degree in applied and mathematical statistics. The new specialists would then work into quality control positions alongside the civilians now being recruited.

It is planned that these officers would finish their one year course in June, 1959. They will be followed by other officers as the program gains momentum.

A glance at the job requirement for one of the engineers will give an idea of the scope and responsibilities involved. Among other duties, several stand out: "responsibility for final decision; authorized to approve . . . actual acceptance of the end product; to recommend design changes; determines by means of engineering knowledge; interprets and evaluates test instructions."

The engineer is placed at a level sufficiently high that his decisions are binding on the Air Force, may entail expenditure of additional funds, and affect delivery schedules. The man works under the general administrative supervision of the AFQCR, but has broad latitude for independent decisions and receives no technical supervision.

Present plans call for engineers to be assigned to AF Plant Representatives offices at Douglas Aircraft, Long Beach, Calif.; Convair, San Diego, Calif.; Glenn L. Martin, Denver, Colo.; General Electric, Syracuse, N. Y.; and A. C. Spark Plug, Milwaukee, Wis. Others will work at the AMC Liaison Office, Edwards AFB, Calif.; AMC Quality Control Activity, Air Force Missile Development Command Test Facility, Denver, Colo.; and the AMC Liaison Office, Patrick AFB, Fla.

While this engineer concept is being applied now to missiles, it is expected that the procedure will be used with all Air Force weapon system procurement in the future. Colonel Schneider summed up the philosophy in a letter to the Air Materiel Areas. He said:

"Quality and reliability are the keystones to any arsenal of missiles. Air Force quality control in the missile era is more important than ever before and will require aggressive, continuous action on your part if quality control is to successfully carry out its new role in the current and future AF weapon system programs."

What's New?

ROY A. WYLIE, *Editor*

When inquiring about "What's New?" items, please mention INDUSTRIAL QUALITY CONTROL

Custom Scientific Instruments, Inc., Kearney, N. J. is now offering a Nicking Jig, Model CS-92, to the plastic industry. The unit is shown in Fig. 1 of the "Proposed Tentative Method of Test for Environmental Stress Cracking of Ethylene Plastics," which appeared in the ASTM Bulletin of December 1956. Also available is a Sampler Notcher for ASTM D-256-54T, Method A and B as well as many fixtures that appear in ASTM Specification.

★ ★ ★

A new model of the Galvanek-Morrison Fluorometer, designed originally for the U. S. Atomic Energy Commission by the American Cyanamid Co. now incorporates provision for analysis of liquid samples for trace quantities of both beryllium and uranium. Produced by the **Jarrell-Ash Co.**, Newtonville, Mass., under license from the American Cyanamid Co., the new JAco G-M Fluorometer extends the scope of the original Galvanek-Morrison instrument from conventional determinations of uranium in solids to include detection of beryllium and uranium in solutions, particularly biological products. The versatility of the Fluorometer permits analysis of any liquid or solid sample inherently suited for fluorometric methods, and renders the instrument ideal for a wide variety of fluorometric determinations seldom within the range of only a single instrument. Interchangeable attachments permit operators to switch quickly from analysis of solid to liquid samples.

★ ★ ★

A new, high precision, motor driven production micrometer which can handle up to 10,000 spherical pieces per hour, as well as rectangles, squares, tapers and other shapes, has been announced by the **Affiliated Manufacturers, Inc.**, 60 East 42nd Street, New York 17, N. Y. Known as a Roller Mike, the new unit is designed to sort and measure small to miniature parts, for precise classification, by thickness, in production quantities or small lots, and with total clearances down to 0.000030 inches. Among the parts which the ROLLER MIKE can sort and grade are mica discs; instrument pivots; miniature steel balls; germanium and silicone dice; machined spacers; bearings; collars; straight and tapered sleeves and pins; platinum and indium spheres and pellets; metal ring guides; plastic and metal washers; and glass beads. The ROLLER MIKE is applicable where mass produced items require sorting or culling out for subsequent high quality close tolerance assemblies, and where high quality and less rejects can be produced by regrading of parts. Automatic feeds can be furnished to provide unattended operation, and provisions can be made for sorted parts to be fed into a continuing process. The Roller Mike is a self-contained unit with removable lid and carrying handle for easy movability. It weighs 32 pounds and is driven by a 110 V 60 cycle, single phase, 3, 25, or 75 RPM motor. The unit has eighteen collecting bins.

are your employees QUALITY-deaf?

Does the work-level listen to everything but hear nothing when it comes to your Quality messages?

If employee indifference and the difficulty of personal coverage in problem areas is of growing concern to you, then you will want to investigate the Elliott Hi-Vision Quality Program.

Here is a well conceived, practical approach to securing employee cooperation on a plant-wide basis.

Details and colorful samples of this effective, low cost means of moving minds in the right direction are yours on request.

See for yourself how other A.S.Q.C. members are solving the employee apathy problem.

ELLIOTT SERVICE COMPANY, INC.
Department 83, Mount Vernon, N. Y.

Please provide me, without obligation, further information and multi-color samples of your Hi-Vision Quality Program.

Name.....

Firm.....

Address.....

City..... Zone.... State.....

ELLIOTT SERVICE COMPANY, INC.

MOUNT VERNON, NEW YORK

With an adjustment difference of 0.001 between the roller ends, a theoretical sorting by groups of 0.00050 inches with good consistency can be achieved. Fragile parts are not harmed by passing through the Roller Mike because the upward-outward rotation of the units rollers assure that fragile pieces travel by their own weight and drop only about an inch into the sorting bin. Price of the basic unit is $1,250.00.

★ ★ ★

Portable equipment for ultrasonic inspection, testing and measuring of metals, ceramics and other materials at "on the spot" locations is now available with the Curtiss-Wright Echoscope, Model 501, a product of the Industrial and Scientific Products Division of **Curtiss-Wright Corp.**, Princeton, N. J. The lightweight portable instrument can be moved to any location or mounted on mobile equipment, to detect defects in metals and materials, to measure wall thicknesses, and for maintenance testing and checking of in-position shafts, axles and running gears on machines. The Echoscope operates on 110-120v. AC current and can be plugged into any standard outlet. Designed for use

in five different operating frequencies utilizing Curtiss-Wright quartz or HiR lithium sulphate transducers, the Echoscope is simple to operate. To inspect any metal, a Transducer is placed against an oiled surface and the reflections are viewed on the five-inch flat faced cathode ray tube. A reflected 'pip' indicates the size and position of the defects in accordance with pre-arranged standards. For measurement purposes, a variable intensity edge-lighted grid pattern is provided on the cathode ray tube face. The Echoscope can test material from a distance up to 30 feet by using extended coaxial cables. Also available for plug-in operation with the Echoscope is the Curtiss-Wright Flaw Calibrator, Model 502, which signals the presence of a flaw by a visible alarm (red light) and an aural alarm (buzzer). It also provides gated selection of the area to be tested and provides amplitude level control for selection of defects over the pre-determined pip size. Special fixtures and transducers are designed for the inspection of complex shaped materials, and where the material inspected is not readily accessible.

★ ★ ★

A new group on industrial inspection lights uses handmade, miniature

DO YOU HAVE A QUALITY CONTROL PRESENTATION PROBLEM?

QUALITY CONTROL AIDS ARE THE ANSWER

Make your presentation more forceful and understandable by the use of these aids.

QUINCUNX
... This device permits your audience to visualize the creation of a normal distribution pattern as well as the results of variables sampling. All beads are self-contained; nothing to drop out. Done in attractive mahagony complete with zipper carrying case.

ATTRIBUTE SAMPLING DEMONSTRATOR
... Complete unit consists of transparent plastic container, opaque colored beads, and wood paddles permitting easy identification of beads at a distance.

SIMULTATORS
... To demonstrate control chart plotting and shift of distribution pattern.

Lightning Calculator Co.
Box 6192
St. Petersburg Beach 6, Fla.

Electronics Division News

Proceedings of the 4th National Symposium are available at $5.00 per copy from the Institute of Radio Engineers, 1 East 79th Street, New York 21, N. Y. Division members not attending the symposium are receiving a free copy as a membership dividend.

Plans for the 5th Symposium to be held Jan. 13-15, 1959 in Philadelphia, Pa. are already underway. This will again be jointly sponsored by the Division, the PGRCQ of IRE and AIEE with the cooperation of EIA. It is also very likely that ASME will be one of the participating sponsors.

The organization of the management committee is just about complete with the division enjoying a good representation. The members selected to date are:

I. W. Schoeninger, general chairman (ASQC)
C. Ryerson, general vice chairman (IRE, AIEE, ASQC)

Program Committee
W. T. Sumerlin, chairman (IRE, AIEE)
R. G. Fitzgibbons, vice chairman (ASQC)
E. J. Rucci, vice chairman (IRE)
R. M. Jacobs, vice chairman (ASQC, IRE)

Publicity Committee
W. Rombach, chairman (ASQC)
E. K. Morse, vice chairman (IRE)
H. Wuerffel, vice chairman (IRE, AIEE)
W. Vickers, vice chairman (AIEE)

Registration Committee
J. Rivera, chairman (ASQC)

Arrangements Committee
J. J. Mackey, chairman (ASQC) (IRE, ASQC)
S. Zwerling, vice chairman
C. Fritz, vice chairman

Proceedings Committee
P. K. McElroy, chairman (IRE, AIEE, ASQC)

Ladies Program
Selma Koury, chairman (ASQC)

Secretary
M. Raphelson (IRE, ASQC)

Treasurer
M. Smith (AIEE, IRE)

lamps designed for medical instruments to produce an unusually clear, sharp beam of light, free from filament shadows and other aberrations found in lights using ordinary flashlight lamps. Very small shaft and lamp diameters permit these lights to be used in cavities which could not otherwise be inspected visually. These inspection lights are available in spot or diffused beam, with short or long extension shafts and with or without rotatable mirrors, magnifying lenses and directional caps. Individual lights can be interchanged instantly on a single handle which also serves as the power source, containing dry cell batteries or a transformer connected to 110 v. outlet. The handle has a sensitive rheostat for varying light intensity. For additional information write, **Welch Allyn Inc.**, Skaneateles Falls, N. Y.

★ ★ ★

A multiple function automatic tester which makes possible 30 individual wiring checks per minute is now in production at the Equipment Manufacturing Division of Allen B. DuMont Laboratories, Inc. The device is capable of selecting a maximum of any five points simultaneously for a given test. Each of the five points

OUR EVER-GROWING FAMILY

With the addition of St. Charles (Ill.) the number of sections in the Society is now 101. The Society is proud to extend a most cordial welcome to the new section.

101—St. Charles (Dist. 12)

Chairman: Stephen T. White
General Electric Co.
De Kalb, Ill.

Vice Chairman: H. Raymond Swensori
Illinois Institute of Technology
Chicago, Ill.

Secretary-Treasurer: Robert A. Messier
Elgin National Watch Co.
Elgin, Ill.

PRECISION PRODUCTION PROBLEMS ?

Here's help from Bausch & Lomb in TOOL DESIGN INSPECTION FABRICATION MEASURING TESTING

NEW! ALIGNMENT INTERFEROMETER

Accurately measures small changes in angle over a range of 30 seconds of arc (±15 seconds). Easy direct scale readings to 0.2 seconds (0.000006").

BENCH COMPARATOR

Exclusive understage illumination—no complex set-ups, no holding fixtures for most work. Magnified silhouettes show errors instantly. Reads to 0.0001" with optional micrometer stage.

STEREO-MICROSCOPES

Magnified 3-D views of tiny parts. Dustproof, shockproof, can be mounted right in machine or fixture. Speeds assembly, inspection. Most complete line, widest field of view.

CONTOUR MEASURING PROJECTOR

Shows magnified silhouettes or surface views. Simple operation, highest precision measurements: to 0.0001", linear; to 1 minute of arc, angular.

OPTICAL AIDS CATALOG

Time-and-money-saving data on Surface Comparators, Industrial Magnifiers, Macroscopes, Microscope Bodies, Micrometer Discs, Wide Field Tubes, Brinell Microscopes, Shop Microscopes.

NEW TOOLMAKER'S MEASURING MICROSCOPE

Quickly measures opaque or transparent objects of any contour. Linear, accurate to 0.0001"; angular, to 1 minute of arc.

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Please send literature on optical production aids checked below:

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TITLE .....
COMPANY .....
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CITY ..... ZONE ..... STATE .....

BAUSCH & LOMB
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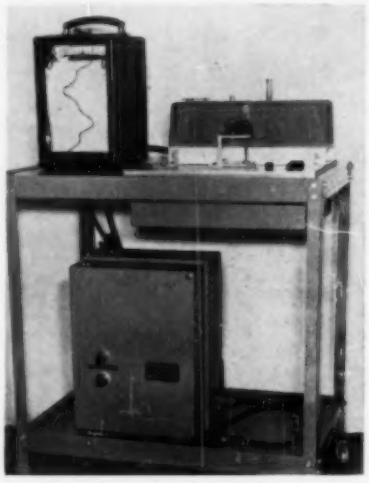
may be routed to any of 22 separate points; that is voltage sources, signal sources, voltage output points, bridges, etc. Tests include continuity (involving broken wires, determining whether the right wires are connected to the right points), megger (the condition of wire insulation) and resistance. The multiple purpose automatic tester has an average speed of one test every two seconds and a capacity of 900 input points, consisting of 30 connectors of thirty points each. Basically, the DuMont instrument consists of three main units: A tape reader, utilizing standard 8 channel tape, programs the various test procedures by means of perforations punched out on the tape. In the main body of the machine, selector switches receive information transmitted by the tape reader, routing the switches to the connector terminals or points to be tested. The desired test is then applied to those points. Selection of desired input points, application of required test to points, and the testing are all done automatically. A "readout" (a serial entry printer) automatically records the test step number and test result. The multiple function automatic tester can be used on any unit where there is a multiple number of points to be tested. For additional information contact Military Operations Sales Department, **Allen B. DuMont Laboratories, Inc.**, 760 Bloomfield Avenue, Clifton, N. J.

Chemical Division News

The success of the "Statistical methods for process development" course which was held at Harvard Business School in January may lead to repeating the course next fall.

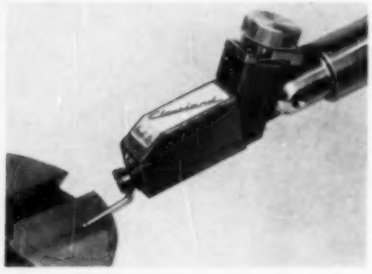
Mr. Alfred J. Kukla, Aluminum Company of America, has been appointed General Chairman of the Second Annual Technical Conference of the Chemical Division which will be held at the Hotel Statler, Buffalo, N. Y., October 2-3.

★ ★ ★



Industrial Gauges Corp., West Englewood, N. J., announces a new quality control instrument which measures and records diameter deviations in lengths of such materials as thread, wire, suture, monofilament, etc. The electronic instrument inspects any convenient length of material ranging from approximately 0.001 to 0.100 inches in diameter. It was designed primarily for production inspection applications and may be mounted on a portable table or in a fixed location. Sample lengths of material are taken directly from the production line, run through the instrument's gaugehead, and the operator adjusts production equipment immediately when diameter deviations fall outside allowable limits. The gauge is set for inspection by adjusting a micrometer spindle to the nominal diameter of the material. This enlarges an aperture so that when the material being inspected is in front of it, the amount of light which passes over and under the material is equal to the amount of light which passes through a second fixed aperture. Thus, when the diameter is correct, the same amount of light will pass through each aperture, and "measuring" and "reference" phototubes will be energized equally. When diameter deviations cause the measuring phototube to receive more or less light than the reference phototube, the photo-electric circuit becomes unbalanced and electronic circuits within the measuring console activate the recorder which records the diameter deviations on the chart. The gaugehead contains the light source, lens system, diameter setting mechanism, phototube zero-setting control, ceramic pulleys which guide the material through the light beam, measuring and reference phototubes, and a preamplifier. The measuring console includes the power supply as well as amplification and translation circuitry.

★ ★ ★



To overcome the danger of damage to high precision gage mechanisms usually considered to be highly fragile, **Cleveland Instrument Co.**, 735 Carnegie Ave., Cleveland 15, Ohio, has developed the "Protector Gage Tip". Providing protection against blows from all directions, even head on, this new tip and the Cleveland INDI-AC Electronic Height Gage still remain accurate to millionths of an inch. Accidental blows, from handling or mistakes in setup, deflect the Gage Tip thus preventing the transmission of the blow and subsequent damage to the gaging element. In addition, the Protector type increases the versatility of the INDI-AC electronic height gage by permitting its use in many previously inaccessible areas such as hole or groove bottoms. The friction loaded ball joint mounting will slip if any

QUALITY CONTROL MANAGER

Rapidly expanding young precision magnetic tape manufacturer requires quality control manager to establish and organize quality control program.

Engineering background plus knowledge of statistical applications desirable. Minimum 3-5 years supervisory experience in continuous processing industry.

Since company's products are intended specifically for video, computer, and instrumentation applications, future expected growth makes this position one of extremely high potential. Forward all information relative to experience and education, as well as salary requirement to:

Box 14W4
American Society for Quality Control
Room 6197, Plankinton Bldg.
161 W. Wisconsin Ave.
Milwaukee 3, Wis.

pressure greater than 10 to 12 ounces is applied to the gage tip. Normally, gaging pressure is less than ½ ounce, thus the gaging tip will not slip or interfere with normal gaging use.

★ ★ ★

A new automatic capacitance indicator is in production at **Barnes Development Co.**, 213 West Baltimore Pike, Lansdowne, Pa. The new Barnes Capacitance Indicator is a versatile, automatic instrument, incorporating the General Radio Type 716-C, Capacitance Bridge as its basic bridge unit. The self-balancing indicator automatically measures capacitance and dissipation factor in an average time of 7 seconds. Capacitance range is 100 uuf to 1.1 uf, in four ranges, and Dissipation Factor range is 0 to 16 percent, in three ranges. All range switching is fully automatic. Accuracy is equal to that of the basic bridge unit. The Capacitance Indicator is available with digital readout, for use with any punched card or tape system, or with servo (voltage) readout for use in obtaining a graphic record of values, with recorders such as the Barnes Data Recorder.

★ ★ ★

M & S Equipment Co., Inc., 380 Darwin Drive, Snyder 26, N. Y., has developed a new space saving storage cabinet to protect gages and precision cutting tools. The gage storage units occupy only 2.9 square feet of floor space yet provide up to 70 square feet of readily accessible storage space, accommodating as many as 1092 tools, gages, taps, dies, reamers, form tools, etc. Systematic indexing

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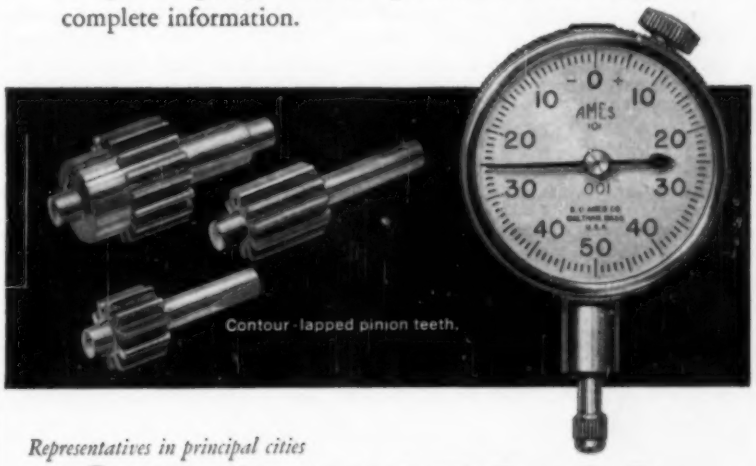
have contour-lapped pinion teeth for greater accuracy

Because tooth form determines how well pinions mesh—Ames hardens, contour laps, and carefully inspects pinions for perfect tooth form and finish. The result: Pinions that mesh perfectly, and a complete absence of accuracy-destroying "play". This extra attention to detail is typical of the Ames manufacturing approach. It helps explain why the lifetime cost of Ames Dial Indicators is lower, and why so many companies specify Ames as "preferred". Write today for complete information.



Contour-lapped pinion teeth.

Representatives in principal cities

B.C. AMES CO.

32 Ames Street, Waltham 54, Mass.

MANUFACTURERS OF MICROMETER DIAL GAUGES • MICROMETER DIAL INDICATORS

of drawers and compartments offers maximum convenience. Drawers will not bind or sag when fully loaded; safety hooks prevent unintentional removal, yet drawers are easily removable when desired. Pressure sensitive index labels are supplied. Individual tool compartments with Masonite sides and oil resistant liners assure full protection against chipping or nicking of stored items and provide dust-free storage with no danger of mechanical damage. Standard single depth drawers have 39 compartments for gages up to 1¼ inches in diameter; double depth drawers have 14 spaces for gages up to 2½ inches in diameter; dividers are adjustable to provide varied compartment sizes. Three models are now available to meet individual requirements. All models are mounted on casters and finished in cabinet gray.

* * *

New Literature Available

Complete information about Leeds & Northrup temperature control equipment for stress-rupture and creep testing is now available in a new two-page data sheet just published by the company. In addition to the control system, this sheet also lists and illustrates auxiliary equipment usually recommended for production and laboratory testing. For your copy of Data Sheet 247 (1) write Leeds & Northrup Co., 4934 Stenton Avenue, Philadelphia 44, Pa.

To add to the versatility of the Spectronic 20 Colorimeter-Spectrophotometer, the Bausch & Lomb Optical Co., Rochester 2, N. Y., has made available the following seven analytical procedures for steel:

1. Manganese in Plain Carbon and Low Alloy Steels (Periodate Method)
2. Nickel by the Dimethylglyoxime Method
3. Silicon by the Silicomolybdate Method
4. Molybdenum by the Thiocyanate-Stannoun Chloride Method
5. Phosphorus by the Molybdenum-blue Method
6. Chromium and Manganese-Simultaneous Determination in Steels
7. Copper by the Alpha-Bensoinoxime Method

The price of the seven methods is $12.00 without binder. The binder is $2.00 extra. The B & L Industrial Methods Manual introduced about a year ago and containing six analytical procedures for aluminum will accommodate this new steel section and other sections which are planned for the near future. The manual is priced at $20.00.

Custom Scientific Instruments, Inc., 541 Devon Street, Kearny, N. J., has reecntly published catalog No. 58 containing illustrations and brief descriptions of 50 different units. These units include testing and calibration instruments and fixtures that appear in ASTM Designation, Federal, Military and other specifications. The instruments are used in Textile, Plastic, Rubber, Paper, Cement and Insulation manufacturing processes.

Profitable applications of ultrasonic inspection methods and equipment to quality control, production testing and preventive maintenance are described fully in the booklet, "Inside Information on Ultrasonic Testing" newly published by Sperry Products, Inc., Danbury, Conn.

YOUR copy of Vol. 5, 1958

TEXTILE QUALITY CONTROL PAPERS

Published by the Textile Division, ASQC, is now available.

— 131 pages —

Here are 13 papers in a bound volume that were selected from the program of the Eighth Annual Textile Division Conference held in January, 1958 at Clemson College, Clemson, South Carolina, as well as additional papers that have been presented at other meetings.

These papers cover all of the technical aspects of the Textile industry and offer to the conscientious reader an opportunity to enlarge upon his practical knowledge and background.

Order Your Copy Today By Mailing The Attached Coupon.
Price $5.00

ASQC, 161 W. Wisconsin Ave.
Milwaukee 3, Wis.

Please send me ———— copies of the Textile Quality Control Papers, Vol. 5, 1958 at $5.00 per copy. Enclosed $————.

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Make remittance payable to American Society for Quality Control.

3-58

REPORT OF NOMINATING COMMITTEE

The Nominating Committee has given careful consideration to all persons suggested for the American Society for Quality Control elective positions for the year 1958-59 and recommends the following slate.

For President:

C. E. Fisher
Bell Telephone Laboratories
New York, New York

For Vice Presidents:

Clarence R. Burdick
Houdaille Industries, Inc.
Detroit, Michigan

A. V. Feigenbaum
General Electric Company
New York, New York

J. Y. McClure
Convair
Fort Worth, Texas

Ellis R. Ott
University College
Rutgers University
New Brunswick, New Jersey

For Executive Secretary:

Leslie S. Eichelberger
A. O. Smith Corporation
Milwaukee, Wisconsin

For Treasurer:

Allan M. Hull
United Air Lines
San Francisco, California

Each of these persons has been contacted and has agreed to allow their names to be placed in nomination and to serve if elected.

section briefs

ALBANY . . . The January meeting was a joint meeting with the ASA. Carl O. Baumann, Monsanto Chemical Co., spoke on "Statistics of destructive testing." At the problem session, E. G. Bianco, General Electric Co., lead a discussion on "The utilization of life test data for QC purposes." Michael Flannagan, Marchant Co., displayed the latest models of calculators.

Two courses will be sponsored during the spring by the section. E. Davis and W. J. Mac Farland, General Electric Co., will teach the advanced QC course. E. G. Bianco will teach "Life test and failure phenomena from the QC standpoint."

ALLENTOWN-BETHLEHEM . . . At the first meeting of the new year, Dave Hilder won a free meal by estimating P of a bead box with uncanny accuracy. Robert Wareham entertained the group by showing and discussing the Johns-Manville Corporation's QC training film.

BALTIMORE . . . At the January meeting, an audience of close to 100 thoroughly enjoyed a talk on "Design of experiments" given by Wm. J. Youden, statistical consultant of the National Bureau of Standards. Among the guests were many engineers and scientists from Baltimore industries including a number of members of ACS and other chemical societies.

On Apr. 8 one of the well known members of the Baltimore section, Dr. Geo. Vlases, Jr. of the Bureau of Customs, will discuss sampling. Based on his many years of experience in this field, the talk should be very informative.

BATTLE CREEK-KALAMAZOO . . . On Apr. 16 at 8 pm in the Physics-Mathematics Building, Michigan State University, Dr. E. Wylie, professor of forest products, will speak on the subject "Modern QC in an old industry." He has written numerous articles on quality control and is well versed in this field.

The section is conducting three courses in statistics—one course is basic in nature, one advanced, and the other is a course in sampling. The courses are being taught by section members Dr. Fred Beeler of Western Michigan University, Dr. Osmer Carpenter of the Upjohn Co., and William Snideler of the Eaton Mfg. Co. These courses are given for the purpose of promoting QC and serving the demands of the community.

BINGHAMTON . . . The hail, sleet, and snow thrown by the weather man at the Southern Tier the evening of our January meeting was bravely challenged by a large percentage of the membership.

Nomination of officers for the 1958-59 season will be included in the Apr. 15 meeting. Ted Lemoncelli and Rocco L. Fiaschetti are co-chairmen of the nominating committee.

BIRMINGHAM . . . On Jan. 9, a meeting sponsored jointly by the Auburn chapter of SAM and the section, was held at the Alabama Polytechnic Institute. Dr. Harold Klontz discussed "Statistical applications and inventory control."

The B. F. Goodrich Co., Tuscaloosa, will be host for a plant trip on Apr. 10.

BOSTON . . . The section is preparing for its new spring seminar in which "New QC techniques" is to be presented. Exact date and place will be forthcoming.

BUFFALO . . . Dr. Frank Grubbs of the Aberdeen Proving Grounds was guest speaker at the February meeting which was held at Niagara Falls.

BUZZARDS BAY . . . Charles D. Ferris, manager of quality control of Mohasco Industries, discussed "Assigning responsibility for quality in textile manufacture" at the January meeting. A large delegation of 25 from Berkshire-Hathaway attended in addition to members and guests. Kenneth Bennett presided.

CHARLESTON . . . Our educational committee has been very active with a ten-week course in advanced SQC which began Feb. 26. The basic course (same as last year) will be presented later.

Local retail and wholesale dealer representatives will be invited, through the Chamber of Commerce, to attend our Mar. 20 meeting.

CHATTANOOGA . . . During January, a plant tour was made of the Brock Candy Company here in Chattanooga.

1957-58 MEMBERSHIP ROSTER IS NOW AVAILABLE

The new 1957-58 Membership Roster has just come off the press. Initial mailings are now being made to those who requested their copies in advance last November. A limited number of copies were overrun and will be sent free on request while they last. Use the coupon below or a separate card if you prefer.

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CINCINNATI . . . The large attendance at the Jan. 25 all-day conference was partially due to the excellent publicity—one TV and two radio programs were presented.

On Jan. 16, Paul A. Robert addressed an organizational meeting of 72 people in Lexington, Ky. The first formal meeting of the sub-section was held Feb. 13. Both the Lexington Chamber of Commerce and the section have worked hard to get a sub-section for central Kentucky.

On Jan. 19, the pictorial section of the Cincinnati Enquirer carried a two-page spread on quality control. In addition, Mayor Clancy of the city of Cincinnati proclaimed January 25 as Quality Control Day. The "official proclamation" is shown at the right. Mayor Clancy (left) is congratulating Society President Leon Bass. On Mr. Bass' right is section chairman William E. Barker. Both Mr. Bass and Mr. Barker are with the Jet Engine Department of the General Electric Co.

The section recently assisted in the reception of a group of Spanish engineers who are here in this country to review QC methods.

The large advance registration for the spring educational series is indicative of the great interest in this activity.

On Apr. 16, Roy A. Wylie of the Micro-Switch Div., Minneapolis-Honeywell Regulator Co., will discuss "SQC solves manufacturing problems."

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PROCLAMATION

CINCINNATI QUALITY CONTROL DAY

In recognition of the efforts and work of this organization and its members in obtaining quality products for use within our national economy.

IN WITNESS WHEREOF, I have hereunto set my hand and have caused the seal of the City of Cincinnati to be affixed this twentieth day of January in the year of our Lord, Nineteen Hundred and Fifty-eight.

Donald D. Clancy
Mayor

COLUMBUS . . . C. A. Bicking, manager of the QC branch, research and development division of the Carborundum Co., will speak at the April meeting. In his talk, Mr. Bicking will discuss the factors for a good design of experiments. Recent developments in this field will be presented together with peculiarities of industrial experimentation. Simple designs for a wide variety of industrial uses will be illustrated. Mr. Bicking is a Fellow of the Society.

CORNING-ELMIRA . . . Despite extremely poor weather conditions, approximately 50 persons attended an all-day conference held on Jan. 25. The theme of the conference was "Reduce costs through QC." The section would like to express its appreciation to all the speakers and particularly to John H. K. Kao of Cornell University, M. Gryna, Jr. of Esso Research and Engineering Co., and George A. Metz of IBM Corp., who had to brave hazardous driving conditions to contribute to the success of the conference. Thanks are also due to A. P. Stergion, conference chairman, for arranging a wonderful program.

CUMBERLAND . . . Edward J. Delate, a specialist in the film department of E. I. duPont de Nemours & Co., spoke on "Resampling in a chemical process" at the January meeting. He demonstrated the use of simple control chart techniques and successive differences as one approach to the resampling problem.

DALLAS-FORT WORTH . . . Joel Bower gave a provocative talk, "Controlling quality control," as was evidenced by the unusual turnout of over 100 members and guests.

"Planning inspection criteria," to be presented by H. L. Ingram at our Apr. 10 meeting, promises to be another in a line of outstanding programs.

DENVER . . . H. N. Tignor, manager of the quality control laboratory at Martin Aircraft, spoke to the section on the "Role of the QC laboratory in a research and development program." The organization, physical plant, and accomplishments of the laboratory were described. Coordination of purchasing for the development phase and the use of the team approach in problem solving was emphasized. The question and answer period proved helpful to those engaged in similar operations and in this phase Mr. Tignor was assisted by other members of the Martin QC staff.

Dale Lobsinger, together with Jack Murphy and Larry Straw, all of United Air Lines, recently discussed QC and the statistical approach to air line operations with a Japanese QC specialist study team headed by Noboru Yamaguchi, manager of manufacturing division, Tokyo Shibaura Electric Co., Tokyo. Mr. Philpot of the International Cooperation Administration accompanied the group and served as moderator.

EVANSVILLE-OWENSBORO . . . Dr. Howard Wilson, an educator, lecturer, and training consultant, was the speaker at the Jan. 21 dinner meeting held at Gabe's Steak House in Owensboro. Dr. Wilson's subject was "Overcoming resistance to change."

GREATER MUSKEGON . . . Thirty members and guests of the section met at Doo Drop Inn on Jan. 9 to hear Harold Sharpe, manager of industrial relations, Norge Division. Mr. Sharpe's topic was "Union thinking on QC and automation." A lively question and answer period followed the presentation.

On Apr. 10 the section will meet at Holiday Inn in Grand Haven for dinner. Following dinner, the group will visit the Keller Tool plant, a division of Gardner-Devner Corp., manufacturers of pneumatic tools. John Welch, QC supervisor, will be in charge of the plant visitation.

HAMILTON . . . The Jan. 15 joint meeting of the University of Western Ontario and Hamilton sections, which took the form of a panel discussion, "Managements' outlook on SQC," proved most interesting. Many thanks to the management representatives who acted on the panel.

With Society President Leon Bass booked to present a paper on "Vendor certification" on Thursday, Apr. 17, we anticipate another well attended meeting of members and interested guests.

HAMILTON-MIDDLETOWN . . . January was a very busy month with the section attending a local meeting and the 7th annual quality conference. At the Jan. 8 top management night meeting, the section was honored to have as guest speaker C. Nung, vice president of the Mallory Co. Mr. Nung presented a very enlightening talk on quality control and management.

HARTFORD . . . Ralph E. Kuehn, manager of reliability of IBM Corp., explained in detail the organization of a reliability group, how it functions throughout the plant within the various departments, and the results obtained from the group. Bad weather limited the number in attendance but Mr. Kuehn's talk was well received.

Two levels of SQC classes have been started. "Introduction to statistics" and "Intermediate statistics" are being taught at the Royal McBee Corp. by section members.

HUNTSVILLE . . . At the January meeting held at Decatur, J. E. Broughton, chief, quality assurance unit, Army Ballistic Missile Agency, spoke on "Quality assurance as a consumer function" emphasizing the engineering aspects of quality assurance.

The election of officers nominated at the March meeting will be held in April.

INDIANAPOLIS . . . On Jan. 24 the members and guests of the section met at Butler University to hold their 2nd annual Indiana clinic. There were many interesting exhibits to help the QC people in their work. The clinics were well executed and well received. Dinner was followed by a very interesting panel discussion.

Charles R. Hicks, professor of mathematics at Purdue University, gave a very interesting and enlightening talk on "Risks involved in significance tests and control charts" at the Feb. 18 meeting.

KANSAS CITY . . . The regular January meeting featured William Rutherford of the Midwest Research Institute in an interesting presentation of "Statistics in a research organization." Mr. Rutherford has been active in the fields of statistics and quality control since his graduation from the University of Missouri. Much of his background has been in the aircraft industry. Preceding the meeting was the regular educational program featuring product displays of two gauge manufacturer's representatives.

The March meeting will feature Dr. Paul Olmstead, consultant in engineering statistics of the Bell Telephone Laboratories, in a talk entitled "Philosophical implications of SQC." The pre-dinner educational program will be a product display of the Marley Co., manufacturers of water cooling towers and water cooling equipment.

LANSDALE . . . Our education night meeting held on Jan. 9 was a success due entirely to Daniel Meckley, III, of the York Corp. As speaker, his topic "Your future in QC" really hit home to those students attending. One of the films which supplemented his talk was "Fundamentals of QC." Co-incidentally, this was a film made by the York Corp. (Shown in the above photo from left to right: speaker Daniel Meekley, III; section vice chairman Curtis Lawrence, section secretary Wilbur Haas, section treasurer Benjamin Nase, and section chairman Charles G. Weidmann.

Our Apr. 10 meeting will be held at Superior Tube Co. The speaker will be Harry Pool, presenting the topic "A glimpse at a quality control course, as conducted at Superior Tube." This course is a capsule version of an instruction course offered to many industries in the area by Superior Tube Co.

LOS ANGELES . . . Intimate knowledge of the functional type was evident in every word spoken by Stan Zemansky, chief purchasing agent of North American Aviation, Inc., Autonetics Division. With this solid introduction to purchasing and quality control he pointed out ways and means of achieving closer cooperation.

LOUISVILLE . . . On Jan. 13, after a delicious dinner at Bellarmine College dining hall attended by 30 members and the guest speaker, the members met in the Cardinal Room for the regular business meeting. At this meeting the membership voted unanimously that the membership be assessed at the rate of $1 per member for the total current membership for the purpose of supporting the National Office in its financial drive. The assessment was voted to be taken from the section treasury for this purpose.

The educational committee announced that the third course of the year in "Basic quality control" was off to a fine start with a total enrollment of 54 students.

The evening came to a most successful ending after a very interesting presentation "Do you have a unified QC program" by Fay Carlson of Warner Brake and Gear Co.

MEMPHIS . . . Society President Leon Bass, manager of quality control for Jet Engine Div., General Electric Co., was the speaker at the Jan. 17 meeting. His topic "The nature of quality control" was well received. Mr. Bass discussed the future needs of the Society for members, money, and professional status.

For the Mar. 21 meeting, the section is pleased to have Dr. Paul S. Olmstead of Bell Telephone Labs and a member of the editorial board of "Industrial Quality Control" whose topic will be "Statistical QC in engineering research and development."

Frank Caplan, Jr., superintendent of QC, Westinghouse Electric Corp., Atomic Fuel Dept., will speak on "Incoming inspection and vendor relations" at the Apr. 4 meeting.

The section is sponsoring a course in SQC at the extension school of the University of Tennessee. The course is being taught by William W. Heiskell of Firestone Tire and Rubber Co.

METROPOLITAN . . . Several members of the section have visited foreign countries under the U. N. point four program. A selected group of these will discuss the applications of QC in the countries they have visited at a panel meeting to be held Mar. 25. Prior to the meeting, the section will be conducted on a tour of the U. N. Building. Following the tour, a dinner will be served in the U. N. Cafeteria. One of the assembly rooms will be used for the meeting.

MID-HUDSON . . . William Kehayias of IBM Corp. spoke on "Some fundamentals of machine capability as applied to electronic test equipment" at the January dinner meeting.

The guest speaker for the April meeting will be John W. W. Sullivan whose topic will be "Statistical methods in steel technology."

MILWAUKEE . . . It appears that the section has had a full share of national officers this year, and the February meeting was no exception. Henry Becker, division metallurgist, process control and inspection, American Steel and Wire Div., U. S. Steel Corp., was the speaker. Mr. Becker, a vice president of the Society and one of its early members, spoke on "Statistical methods in metallurgical problems." It concerned various testing procedures and their comparative reliability. It also concerned the so-called accepted inherent

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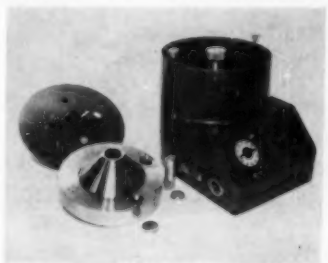

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(82) A. J. Duncan, "Use of Ranges in Comparing Variabilities," Reprint from IQC Vol. XI, No. 5, February 1955	.25
(83) Charles R. Hicks, "Fundamentals of Analysis of Variance," Reprint from IQC Vol. XIII, Nos. 2, 3, 4, August, September, October, 1956	.45

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variations which we seem to accept as inevitable but which are often greater than we are bargaining for. The talk was well received and a long discussion period followed.

Prior to the meeting, two training sessions were held on the "F-test" and "Run and reset technique." As usual these classes were heavily attended.

MINNESOTA . . . On Feb. 10 the section was treated to a down to earth discussion of machine capabilities by Brent C. Jacobs, Jr. of Minneapolis Moline. His talk was illustrated with some very fine examples drawn from his industrial experience.

The Apr. 14 meeting will be a plant tour of the IBM Corporation's facilities at Rochester.

NEW HAVEN . . . On Jan. 7 the section conducted a plant tour of the Revere Corporation of America.

G. R. Scheel, assistant director of QC and inspection of the Sonotone Corp., will present a talk on "Solder joint quality" at the Apr. 9 meeting.

OMAHA-LINCOLN . . . Marchio's in Omaha was the site of the Jan. 10 meeting. Following dinner, I. O. Karraker of Western Electric spoke on "Quality assurance—an essential part of the Western Electric manufacturing process." Mr. Karraker is assistant superintendent of quality assurance.

PHILADELPHIA . . . At the Jan. 9 meeting an excellent joint meeting with the ASA was conducted by an outstanding panel comprised of experimental scientists Dr. Menduke, Dr. Free, and Mr. Ciminera. They discussed the various procedures used by the biometrician, the pharmaceutical worker, and the researcher in the evaluation of clinical testing.

On Mar. 20 Dr. Rudolf Drenick of the Bell Telephone Labs will present a talk on "Preventive maintenance theory" to a joint meeting of the section and the professional group on component parts of IRE. Dr. Drenick is a theoretical physicist who evaluated German documents concerned with the V-2 missile and has done considerable theoretical work on problems encountered in the electronics industry.

PITTSFIELD . . . Ladies night was held at the Sprague Electric Co., North Adams. After an excellent tour of the research lab and other facilities a steak dinner was enjoyed by 38 members and guests at the Howard Johnson Restaurant. Following dinner, a 30 minute movie was shown on "The human relations aspect of quality control."

"The **you** attitude—a new response motivation" will be the subject of the May meeting. Ralph E. Burt of the National "You" Association will enlighten section members on new methods of motivation responses. The best QC ideas and plans are useless without the ability to "sell" the direct labor people that QC begins with the operator and is no better than what he performs.

The Massachusetts Society for Professional Engineers held an excellent dinner dance program at the Eastover Resort in Lenox on Feb. 18. A large attendance by members of the section made the total attendance swell to over 60 persons. Dinner and dancing to the music of Red Robinson's Orchestra was held at the Tally-Ho Resort.

RHODE ISLAND . . . C. E. Fisher, Society vice president and a member of the technical staff of Bell Telephone Labs, was guest speaker at the January meeting. Mr. Fisher's subject of "Aims and objectives of our Society" was well received.

At the Apr. 17 meeting our guest speaker will be Harmon S. Bayer, quality control consultant, who will speak on "Organizing an effective quality control program."

ROCHESTER . . . On Jan. 21 a group of about 250 heard Dr. Howard S. Coleman, vice president of Bausch & Lomb Optical Co., explain "How QC is used by the product designer." Actual examples were effectively used by Dr. Coleman.

The gaging and measurement sub-group attended an interesting and informative lecture on "Progress in optical gaging techniques" given by James Huff of Optical Gaging Products, Inc.

Election of officers will take place at the Apr. 8 meeting, which will be the last formal meeting of the season.

Rochester Institute of Technology will offer its 15th annual course in "QC for chemical industries" June 23-July 2.

SAN FRANCISCO BAY AREA . . . On Apr. 14 the section will hold its monthly meeting at Oliver's in South San Francisco. Hal Rosoff will speak on Lucky Lager's QC program. After the dinner, the section will tour Lucky Lager's San Francisco Brewery. The tour will be restricted to SQC members only.

SOUTH BEND-MISHAWAKA . . . On Jan. 16 the section was privileged to hear a highly informative talk by C. C. Capel, chief engineer for the Indiana Bell Telephone Co., entitled "Maintenance of reliability and equipment."

SOUTH TEXAS . . . The section met on Jan. 28 to hold its always highly successful annual stag party.

SOUTHERN CONNECTICUT . . . The plant visitation at Norden Ketay Corp. on Jan. 8 with Howard F. Burbank, quality control engineer as host and principal speaker was enjoyed by all who attended.

We are looking forward to Apr. 9 when R. Shaw Goldthwait, quality control manager of Cullver Insulated Wire Co., will present his talk on "Quality control in the production of wire and cable."

TOLEDO . . . A most informative talk covering the determination of tolerances through use of statistical techniques was given by Morris M. Lightstone, manager of the quality analysis and publications department of Chrysler Corp. From an engineering and manufacturing point of view, Mr. Lightstone explained a more precise method of setting specifications. Margaret A. Tobin, QC engineer at the Textileather Div., General Tire and Rubber Co., was moderator for the event.

C. G. Rittenhouse, Eastman Kodak Co., will be guest speaker at the Apr. 3 meeting. His subject will be "Management reactions to SQC in production."

"Basic statistical quality control," sponsored by the section, received the honors of having the largest enrollment—107 students—of all evening session courses held at the University of Toledo during last semester.

TORONTO . . . On Jan. 8 the section enjoyed a lecture on "Work simplification" by Fred Duff of the British American Oil Co., Ltd. Many interesting demonstrations of practical applications were given which were highly appreciated by the audience.

Peter de Karwin, Canadian General Electric, presented a paper on the applications of industrial television. A view camera and monitor set were available and the practical application was demonstrated.

TUCSON . . . The February QC clinic on "Statistical aspects of test position differences" was led by Warren R. Clemens, QC engineer, Hughes Aircraft Co. After-dinner speaker C. W. Pickrell spoke on the subject "El Lugar Abonde Vivemos" which, translated means "The place where we live." Mr. Pickrell regaled his audience with tales of Tucson's early days and answered such questions as "What's a running iron?" and "Who was Arizona's first cattleman?" A native Tucsonite these days is so rare in our mushrooming community that many of us know very little about our local history.

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SECTION CALENDAR (MARCH 20—APRIL 31)

SECTION	DATE	PLACE	TIME	SUBJECT	SPEAKER
Albany	Apr. 10	University Club	4:30 pm	Problem Session; Vendor Quality Rating	L. G. Harding, IBM Corp.
Baltimore	Apr. 8	Baltimore Memorial Stadium	8:00	Practical Aspects of Sampling	Dr. Geo. Vlases, Jr., U. S. Bureau of Customs
Battle Creek-Kalamazoo	Apr. 16	Michigan State University	8:00	Modern Quality Control in an Old Industry	Dr. Aubrey E. Wylie, Michigan State University
Binghamton	Apr. 15	American Legion Post 89, Vestal	7:00	Statistical Significance	Edward C. Harrington, Monsanto Chemical Co.
Boston	Apr. 16	MIT Faculty Club	6:30	Process Control and Audit	Frank McLaughlin, General Electric Co.
Buffalo	Mar. 31	Chevrolet Engine Plant	7:30	Plant Tour	———
Buzzards Bay	Apr. 8	Conference Room, Continental Screw Co.	8:00	Design and Analysis of Industrial Experiments	Allen Crawford, Esso Research and Engineering Co.
Charleston	Mar. 20	So. Chas. Rec. Center	8:00	Distributors Interest in Quality Control	R. W. Peach, Sears Roebuck and Co.
	Apr. 17	So. Chas. Rec. Center	8:00	Statistical Demonstration Gadgets	———
Chattanooga	Apr. 8	Patten Hotel	6:30	Non-Linear Programming	J. L. Dolby, General Electric Co.
Cincinnati	Apr. 16	Engr. Soc. Bldg.	8:00	SQC Solves Manufacturing Problems	Roy A. Wylie, Micro-Switch Div., Minneapolis-Honeywell Regulator Co.
Columbus	Apr. 16	Jeffrey Manufacturing Co.	8:00	Design of Experiments	C. A. Bicking, The Carborundum Co.
Corning-Elmira	Apr. 8	Elmira	8:00	Process Control in a Job Shop	Frank Caplan, Jr., Westinghouse Electric Corp.
Cumberland	Apr. 1	Fort Cumberland Hotel	6:30	Control Charts in Multi-Stage Batch Processes	Richard S. Bingham, Jr., The Carborundum Co.
Dallas-Fort Worth	Apr. 10	Arlington State College	8:00	Planning Inspection Criteria	H. L. Ingram, Convair Aircraft Corp.
Denver	———	———	———	A Seminar in Quality Control Practices	C. E. Fisher, Bell Telephone Laboratories, Inc.
Greater Muskegon	Apr. 10	Holiday Inn	6:30	Plant Tour—Keller Tool Div., Gardner-Denver Co.	John G. D. Welch, Gardner-Denver Co.
Hamilton	Apr. 17	Canada Westinghouse Auditorium, West Plant	8:00	Vendor Certification	Leon Bass, General Electric Co.
Hamilton-Middletown	Apr. 9	Anthony Wayne Hotel	6:30	Quality Control and Sampling	Keith Ross, Essex Wire Co.
Hartford	Apr. 15	Club Alden	8:00	Practical Applications of Machine Capabilities in a Job Shop	N. B. MacLaren and Raymond B. Fournier, Brown & Sharpe Mfg. Co.
Huntsville	Mar. 27	Decatur	6:30	QC—A Management Tool	Charles Latimer, Nickey Bros., Inc.
	Apr. 16	Decatur	6:30	How to Make an Investigation	S. Patton, Wolverine Tube
Indianapolis	Apr. 15	Butler University, Atherton Center	6:30	Why Design Experiments	Prof. Gayle McElrath, University of Minnesota
Kansas City	Mar. 20	Blue Hills Restaurant	6:00	Philosophical Implications of SQC	Dr. Paul Olmstead, Bell Telephone Laboratories, Inc.
Lansdale	Apr. 10	Superior Tube Co.	7:30	Quality Control as Conducted at Superior Tube Co.	Harry Pool, Superior Tube Co.
Louisville	Apr. 14	Bellarmine College, Cardinal Room	6:00	Quality Control in Short Run Production	Prof. Charles Hicks, Purdue University
Memphis	Mar. 21	Memphis State University	8:00	SQC in Engineering Research and Development	Dr. Paul Olmstead, Bell Telephone Laboratories, Inc.
	Apr. 4	Memphis State University	8:00	Incoming Inspection and Vendor Relations	Frank Caplan, Jr., Westinghouse Electric Corp.
Metropolitan	Mar. 25	U. N. Bldg.	5:00	Quality Control and its Applications Abroad	Four speakers
Mid-Hudson	Apr. 1	Anchor Inn	7:00	Statistical Methods in Steel Technology	John W. W. Sullivan, American Iron & Steel Institute
Milwaukee	Apr. 21	Hotel Stratford	6:00	Management Night	W. W. Kauffman, RCA Defense Division
Minnesota	Apr. 14	IBM Corp., Rochester	———	Plant Tour	———
New Haven	Apr. 8	———	8:00	Control of Solder Joint Quality	G. R. Scheel, Sonotone Corp.
Omaha-Lincoln	Apr. 11	Lincoln	7:00	———	Frank J. Dudek, University of Nebraska
Philadelphia	Mar. 20	Germantown Cricket Club	6:30	Preventive Maintenance Theory	Dr. R. Drenick, Bell Telephone Laboratories, Inc.
	Apr. 17	Germantown Cricket Club	6:30	The Challenge of Reliability	Wm. MacCrehan, Jr., Bendix Radio Division
Pittsfield	Apr. 2	Stanley Club	7:00	The Use of Statistical Methods for Engineers	Leon Bass, General Electric Co.
Rhode Island	Apr. 17	Providence Eng. Soc. Bldg.	8:00	Organizing an Effective Quality Control Program	Oscar Bishop, Consultant
Rochester	Apr. 1	Chamber of Commerce	6:15	Probability Sampling Applied to Tax and Accounting Problems	A. C. Rosander, U. S. Treasury Department
	Apr. 8	Chamber of Commerce	6:15	Sampling by Variables	Prof. Gayle McElrath, University of Minnesota
St. Louis	Apr. 18	Golden Fried Chicken Loaf Restaurant	6:30	Panel Discussion of General Interest	Arnold G. Braun, moderator, Carter Carburetor Corp.
San Francisco Bay Area	Apr. 14	Oliver's	6:30	Lucky Lager's QC Program; Plant Tour	Hal Rosoff, Lucky Lager Brewing Co.
Scranton-Wilkes-Barre	Apr. 17	The Dietrick, Scranton Legion	6:30	Quality Control Improvement and Cost Reduction in Air Frames	J. Y. McClure, Convair Aircraft Corp.
South Bend-Mishawaka	Mar. 20	Bendix Legion Post #284, South Bend	7:30	Vendor-Customer Relations	Sydney F. Knapp, U. S. Rubber Co.
	Apr. 3	YMCA, South Bend	7:30	QC Problems Forum	Joseph F. Gyoles, Bendix Products Division
	Apr. 17	Bendix Legion Post #284	7:30	Machine Capabilities Written into Purchase Orders for Machinery	Ben T. Bernacchi, American Safety Razor Kingsbury Division
South Texas	Apr. 9	Humble Refinery, Baytown	5:00	Plant Tour; Humble's Quality Control	J. C. Dickson and A. R. Stark, Humble Oil and Refining Co.
Southern Connecticut	Apr. 9	Hotel Barnum	7:00	Quality Control in the Production of Wire Cable	R. Shaw Goldthwait, Collyer Insulated Wire Co.
Toledo	Apr. 3	V.F.W. Post #606	6:30	Management Reactions to SQC in Production	C. G. Rittenhouse, Eastman Kodak Co.
Toronto	Apr. 9	University of Toronto	8:00	An Introduction to Sampling Techniques	Walter Pukalo, Inspection Engineering Dept., National Defense, Inspection Services, Electrical Engineering & Electronics Branch
	Apr. 25	Rexdale	8:00	Plant Visit—General Mills	———
W. Massachusetts	Apr. 15	Shelton Hotel, Springfield	8:00	Process Inspection	Graham Morse
Winnebago	Apr. 14	Beaumont Hotel, Green Bay	———	One-Day Clinic	———
Worcester	Mar. 20	Worcester Polytechnic Institute	7:00	Simple Techniques for Adjusting Production Plans by Sales Trends	E. H. Robinson, Johnson & Johnson
Youngstown	Apr. 10	———	———	Finding the Facts Before Setting the Specifications	Julian Toulouse, Owens-Illinois Glass

WINNEBAGO . . . The January meeting was held at the Elk's Club, Appleton. The dinner speaker was S. J. Stellberg, director of quality control, John Deere-Van Brunt Co., Horicon. The topic was "Some of the QC systems used in the John Deere-Van Brunt foundry." Forty-two members and guests were present. A training session conducted by Jim Schoettler preceded the regular meeting.

On Apr. 14 a one-day clinic will be held at the Beaumont Hotel, Green Bay. A very diversified program will be presented which will give coverage to all industry. The speakers engaged for the clinic are leaders in their respective fields of QC. The program chairman for this event is Lee Manders, Champion Paper Products.

WORCESTER . . . LeRoy Lindgren, quality director at the Joy Mfg. Co., presented an interesting talk at the January meeting. His talk "Practical applications of statistics in industry" was well presented and well received. Cal Little, Joy Mfg. Co., assisted Mr. Lindgren in the question and answer discussion period.

YOUNGSTOWN . . . On Jan. 9 a joint dinner and panel discussion was held with the Warren chapter of ASM. The subject for discussion was "Can QC help you." Howard E. Boyer, guest of ASM and ASQC, was moderator. Representing ASM on the panel were John G. Dunn of Republic Steel Corp. and Jack Manternach, Jr., of Heltzel Steel Form & Iron Co. ASQC representatives were Howard C. Dunkle of Republic Steel Corp. and Chester R. Smith of Sharon Steel Corp. and Mallory-Sharon Metals Corp.

On Apr. 10 Julian Toulouse, Owens-Illinois Glass Works and chairman of the Society's Saddoris Award Committee, will be the speaker. His subject will be "Finding the facts before setting the specifications."

SIGNIFICANT DIFFERENCES

. . . Cincinnati—Max Sanders of General Electric Co. has been transferred to the quality control department of Hot Point, Cicero, Ill.

. . . Corning-Elmira—The section is deeply saddened to have to announce that section chairman Herman Albertine has accepted a position with General Electro Dynamics, Dallas, Texas. However, the gloom is strictly selfish. We cannot help but miss the fine job of guiding our section which Herm has done. However, this opportunity couldn't have reached a nicer guy. Lots of luck to Herman Albertine.

. . . Dallas-Fort Worth—Dr. A. W. Wortham, formerly head of operations research in the Semiconductor-Components Division of Texas Instruments, Inc., was recently promoted to director of the quality assurance department. In his new position he will be responsible for qualification and evaluation, reliability assurance, QC, and operations research.

. . . Hamilton-Middletown—John Iams has been promoted to assistant chief inspector in charge of quality control at the Bendix Aviation Corp.

William Horgan has been promoted to quality control supervisor in charge of all materials review board.

. . . Hartford—On Jan. 31 Edward S. Marks retired as QC manager of Pratt & Whitney Aircraft Div., United Aircraft Corp. after 18 years of service. Upon completion of an extensive traveling schedule, he plans to do consulting work in QC management beginning Sept. 1.

. . . Los Angeles—Louis M. Buhler has been named head of the new central QC department of Clary Corp., San Gabriel. Mr. Buhler joined the organization in 1942 and for the last two years has been chief inspector for the entire San Gabriel plant.

. . . Milwaukee—Fred Diesong, Blackhawk Mfg. Co., is leaving Milwaukee to join the staff QC group of the Chrysler Corp., Detroit. Fred has been arrangements chairman of the 5th Milwaukee clinic and we will certainly feel his absence and wish him the best of luck.

The Boston section regretfully announces the death of Edmund Bridge. Mr. Bridge, Quality Control Engineer for the Gillette Safety Razor Company, was killed in an automobile accident. He had recently been appointed Arrangements Chairman of the section.

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. . . New Haven—J. Bradshaw recently transferred from The Revere Corporation of America to the position of quality manager of the Condenser Products Co.

Section chairman D. Albert has accepted the position of QC engineer with Norma-Hoffman Bearings Corp.

. . . Piedmont—Dudley J. Cowden, professor of economic statistics at the School of Business Administration, University of North Carolina, is honorary research associate at the University of London. Until Aug. 1 his address will be Department of Statistics, University College London, Gower Street, London W. C. 1, England.

. . . Rochester—Robert Malach has replaced J. E. Jackson as supervisor of the numerical analysis group of the color technology division of Eastman Kodak Co. Mr. Jackson left Kodak to do advanced graduate work in applied statistics at Virginia Polytechnic Institute.

. . . Scranton-Wilkes-Barre—Section secretary Joseph Gallagher has accepted the position of QC manager of the General Bronz Corp., Long Island, N. Y. Jack Haynes has graciously accepted to act as section secretary to fill the unexpired term of Mr. Gallagher.

. . . South Bend-Mishawaka—Robert Crisman, formerly a QC analyst with the Bendix Products Division of South Bend, is now chief inspector for all divisions of the Fishing Tackle Company of America.

. . . South Texas—The promotion of E. R. Hendrick to the position of senior process statistician in the production coordination department of the Plastics Div., Monsanto Chemical Co., Texas City, was announced recently.

. . . Southern Connecticut—Thomas G. Ragona has accepted a position with Sikorsky Div., United Aircraft Corp., as QC engineer at its Bridgeport plant. Tom was formerly with the USAF QC Branch and had been stationed in various plants in southern Connecticut in his capacity as QC inspector.

SUPERVISOR'S CIRCLE

PAUL A. ROBERT, *Editor*

Precision Products Co. of Cincinnati, Box 130, Norwood 12, Ohio

SPECIAL INSPECTION TESTS

determine the spring-making properties of pre-tempered steel strip

WILLIAM R. JOHNSON

Research Center, Associated Spring Corporation, Bristol, Conn.

The Fatigue Test

When spring steel is to be used in a spring required to deliver a specified number of operating cycles over a given stress range, it is essential to make sure that the material has ample fatigue resistance. For this purpose, Wallace Barnes has developed a fatigue tester for spring steel strip. Since most flat spring applications call for the material to be stressed by bending in one direction only, and not by reverse bending, the Barnes fatigue tester duplicates this service condition, and does not resort to reverse bending as do most other strip fatigue testers.

The test specimen is a flat sample of the stock as finished. The sample is clamped in a fixed holder as a cantilever beam, and one end is deflected by the rotation of an eccentric disc mounted directly on a motor shaft (see Fig. 2). As many as eight specimens can be tested at one time.

The amount of deflection given to each specimen is constant, but the stress can be varied from zero up to a maximum level by altering the length of the cantilever span, simply by adjusting the position of the specimen holders.

The number of bending cycles which each specimen can endure before fatigue failure occurs is measured quite simply by means of a shaft revolution counter.

The stress is calculated from the formula:

$$S = \frac{3EtF}{2L^2}$$

where

E = Young's modulus of elasticity

t = the thickness of the specimen, in inches

F = the deflection, in inches

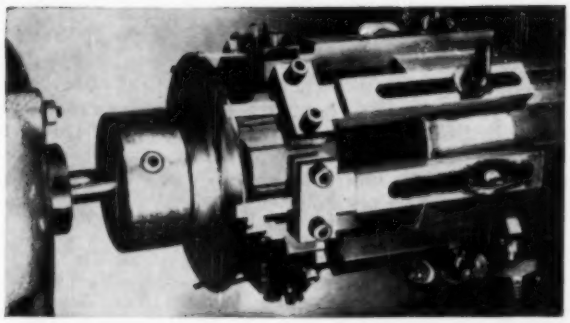
L = the length of the specimen, in inches

A slight correction must be made in the value for L due to the change in the length of the specimen under deflection.

With this fatigue tester, thousands of strip steel specimens have been tested over the past 20 years. Of all the specimens that failed in this tester, over 95 percent failed

EDITOR'S COMMENTS

This is a continuation of the article the first part of which was presented in the February issue.



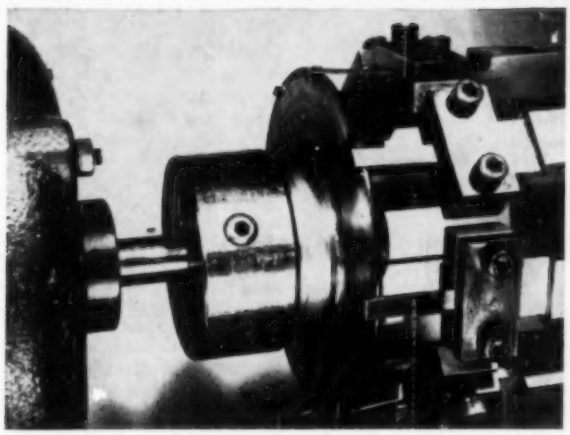


Figure 2—The rotating eccentric disc in this fatigue tester bends the several specimens of spring steel strip in one direction only, duplicating service conditions. The amount of deflection given each specimen is constant, but the stress can be varied by altering the length of the cantilever span of each specimen, simply by adjusting the position of the specimen holders.

in less than 200,000 cycles. In other words, the chances are very great that a specimen which does not fail within 200,000 cycles will run indefinitely without failure.

By using this 200,000 cycle life as the endurance limit for the steel, the time required to test the fatigue resistance of spring steel, for applications where this is an essential property, can be reduced to a reasonable level.

The Break Test

Another very useful quality control test for spring steel is called "the break test." Essentially, this involves bending a strip of pretempered material into a "U" in the jaws of a vise and continuing to increase the closing pressure until the strip breaks (see Fig. 3). The "break distance" is the size of the opening between the jaws of the vise at the moment of fracture.

A "brittle break" or "high break" (i.e., a fairly large jaw-opening) for a specimen of a given thickness and hardness may indicate a lack of ductility due to improper hardening techniques. A "low break" may mean that the steel is too soft or is partially decarburized. An excessively brittle break could mean that springs made of that steel would be likely to fail prematurely. A very low break might mean that springs made of that steel would have a low torque or low elastic limit.

This test is a formalized version of the old-time spring craftsman's traditional practice of testing steel by snapping it between the fingers—a simple test which has been used for many years to determine the suitability of a steel for making clock springs.

Considerable empirical information has been accumulated by the use of this break test, and workable "break" values have been developed for pretempered strip of various thicknesses and levels of hardness. Just as the old-time spring craftsmen preferred to specify steel by its "break" value rather than by its hardness, Wallace Barnes still finds this to be a very useful and informative test.

Test for Formability

A very practical set of tests designed to yield an indication of the formability of pretempered stock has also been evolved. By bending a sample of the stock into a "U" in the jaws of a vise, to a point just short of the fracture point, and observing the radius of the bend that remains when the load has been released, the spring-maker will obtain an indication of the approximate minimum radius to which the stock can be formed by conventional techniques.

A more exact measure of this basic forming property can be obtained by "U"-bending samples of the stock in a simple bottomless die with a punch of known diameter. Clearance between the punch and the die is maintained at the equivalent of one stock thickness on each side of the punch. The smallest diameter punch which will make a 90-degree bend in the stock without fracture is a measure of the ductility and formability of the steel.

Accumulated information of this nature as to the formability of a particular grade of steel is very useful to the spring-maker, since it enables him to predict whether a part can be made of pretempered stock or whether it must be formed of soft material which is hardened after forming.

Other Tests

For general quality control, the old testing standbys of hardness and microstructure are still useful. For the thinner gages of material (i.e., below 0.010 in.), it is important that the hardness test be carried out on the proper tester, such as the Tukon or the Vickers tester. Tests made on the Rockwell tester by using multiple sections of thin samples will give consistent results, but the readings cannot be converted or compared with those which have been correctly taken.

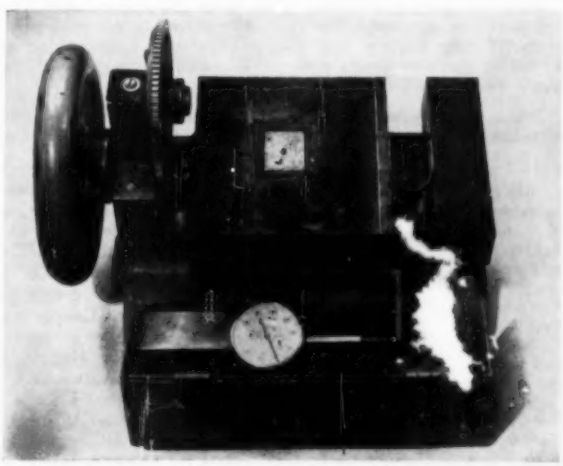


Figure 3—The break test involves bending a strip of spring steel into a "U" in the jaws of a vise and increasing the closing pressure until strip breaks. The "break distance" is the size of the opening in the jaws at the moment of fracture.

The microstructure of each lot of tempered stock must be checked to make sure that no decarburization, oxidation of the grain boundaries, or improper heat treatment has taken place.

Why Test?

In general, the more information which the springmaker can supply the steel supplier, the easier it is for the latter to supply material which is consistently of top quality. Specifying by hardness alone may cause unnecessary rejections of incoming material, or in some cases may also allow inferior material to be accepted. The other tests described herein will prevent either of these from happening. A mutual appreciation and understanding of the many important properties of spring steel and their relation to the performance of the end-product can make life much smoother and happier for customer and supplier alike.

BOOK REVIEWS

W. D. Baten, Editor

26 University Drive, East Lansing, Mich.

INTRODUCTION TO OPERATIONS RESEARCH, by C. W. Churchman, R. L. Ackoff, and E. L. Arnoff, published by John Wiley and Sons, Inc., New York, N. Y., 645 pages, price $12.00. Reviewed by Benjamin Epstein, Stanford and Wayne Universities.

Operations Research (henceforth abbreviated as O.R.) as the authors view it, is "the application of scientific methods, techniques, and tools to problems involving the operations of a system so as to provide those in control of the system with optimum solutions to the problems." During World War II, O.R. methods were applied with success to many logistical, strategic and tactical problems involved in conducting large scale military operations. During the postwar period we have witnessed an increasing recognition of the role of O.R. methods in solving industrial and governmental problems. There has been a rapid development of O.R. methodology during the past ten years and O.R. terms such as systems analysis, model building, feedback, communication and control, team approach, queing are now commonplace.

In 1951, the first book on O.R. was published; *Operations Research* by P. M. Morse and G. E. Kimball published by John Wiley in 1951 summarized some aspects of military O.R. work carried out during World War II. Although this book was pathbreaking, it was quite limited in scope and not a text-book in the usual sense of the word. A detailed, orderly presentation of both the philosophy and techniques of O.R. was needed. In the opinion of this reviewer this need has been met admirably by Churchman, Ackoff and Arnoff. Their text, which grew from lecture material for the "Short Course in O.R." offered annually since 1952 at Case Institute of Technology has two basic objectives: "(1) to provide prospective consumers of O.R. with a basis for evaluating the field and for understanding its potentialities and procedures and (2) to provide potential practitioners with a survey of the field and a basis on which they can plan the further education required for competence with the methods and techniques."

Part I of the book consists of three chapters. In the introductory chapter O.R. is defined and a "systems" and "team" approach to problems is emphasized. In Chapter 2, a detailed discussion is given of an O.R. study conducted on a system as a whole and chapter 3 gives an example of the use of the team approach in an inspection problem.

Part II of the book consists of three chapters which are concerned with very broad and general concepts. In chapter 4 the authors consider conceptual tools and procedures which are useful in analyzing an organization. Chapters 5 and 6 are concerned with the formulation of O.R. problems in large systems.

Next follows a brief section on what a model is, what types of models there are, how to construct and use them in solving problems. This section serves to introduce what is essentially the techniques part of the book. In this part of the book the following important O.R. models are discussed in detail: inventory models, allocation models (usually referred to as linear programming), waiting time (queing) models, replacement models, competitive models (theory of games and competitive bidding). The

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treatment is on a simple mathematical level (by this we mean that little is needed beyond the calculus); proofs are kept elementary and are given in great detail; many excellent examples which illustrate various aspects of theory are worked out in detail.

The book concludes with two sections. One of these is devoted to testing the adequacy of the model, to testing whether the system under study remains stable, and to the question of implementing an O.R. solution. The final section deals with the problems connected with starting and administering an O.R. group in an industrial situation.

Statistical and probalistic methods and ideas pervade the book. One need only cite such topics as the Monte Carlo technique, waiting line theory, (essentially a topic in Poisson and birth and death processes), replacement theory and elements of sampling from human populations. The quality control man and applied statistician will see the notion of a frequency distribution occurring over and over again, and in the section devoted to detecting changes in the system, control charts and the O.C. curve play a basic role. Many of the applications may well be novel to some of the readers.

There is one important message in this book for the quality control man. He should learn from this book that, in solving a problem, he must be aware of how this solution affects an entire system. The optimum solution, narrowly conceived, may be far from optimum when one formulates the problem in all its generality. If quality control methods are to play an important role in industry they must be used with a full awareness of their effect on and interaction with the various components that make up a complex industrial situation.

DESIGNING FOR PRODUCTION, by Edward N. Baldwin and Benjamin W. Niebel, Richard D. Irwin, Inc., Homewood, Illinois, 1957, 645 pages, price $7.00. Reviewed by Wayland P. Smith, Engineering Department, Michigan State University.

The authors have attempted to draw together pertinent information about engineering materials and processes useful to the product designer. The principal engineering materials including ferrous and nonferrous metals, plastics, rubber, and ceramics are discussed in terms of their physical properties. Some emphasis is given to the effect of these properties on processing and to the economics of material selection.

The conventional manufacturing proceses are included as well as sections on heat-treating, finishing, assembly processes, packaging, and automation—not usually found in books of this type.

In any encyclopedic work such as this, it is easy for a reviewer to question certain omissions as well as inclusions. This book is no exception. There appears to be a lack of consistency in the depth and breadth with which different topics are treated.

The goal of the authors is a worthy one. For the person who is technically trained and desires to broaden his knowledge about engineering materials and manufacturing procesess and their inter-relation-ships, the book is recommended as a good introduction.

KONTROLL-KARTEN (in German: Control Charts), author and publisher—Ausschuss fur Wirtschaftliche Fertigung, Frankfurt on the Main, Germany, 5½ × 8¼, 31 pages, 1956. Reviewed by N. L. Enrick.

A presentation of frequency distributions, measures of dispersion, and control charts for averages and dispersion, using examples from industrial applications.

INDUSTRIELLE QUALITATSKONTROLLE (in German: Industrial Quality Control), by H. Lustig and J. Pfanzagl, published by Austrian Statistical Society (Osterreichische Statistische Gesellschaft), Vienna, Austria, 8 × 11¾, 120 pages, $4.20, 1957. Reviewed by N. L. Enrick.

This paper presents 50 examples of industrial quality control applications, demonstrating the use of frequency distributions, sampling plans and control charts. Special attention is devoted to the statistical aspects of realistic tolerances and to the evaluation of cost factors in the quality control program. Since the examples are presented in a clear and concise manner, having been drawn from a wide variety of industrial applications, this book should be of considerable value to those teaching quality control and those who are seeking to expand their own industrial applications of quality control in their work.

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MARCH

. . . 20-21—Cost Control Through Engineering, North Carolina State College, Raleigh, N. C., sponsored by the Textile Engineering Division of ASME, contact E. Lee Harrisberger, Department of Mechanical Engineering, North Carolina State College, Raleigh, N. C.

. . . *23-Apr. 4—Fourth Annual Advanced Statistical Quality Control Institute, University of Connecticut, Storrs, Conn., sponsored by New England sections, ASQC, contact R. M. Story, Jr., Box U41, University of Connecticut, Storrs, Conn.*

(Continued on page 40)

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JUNE

. . . **9-27**—Indiana Executive Development Program, Indiana University, Bloomington, Ind., sponsored by the School of Business, Indiana University, contact Thomas R. Bossort, Jr., Director, Indiana Executive Development Program, School of Business, Indiana University, Bloomington, Ind.

. . . **15-July 25**—Seventh Annual Advanced Management Seminar, University of Washington, Seattle, Wash., contact Professor Jim Rosenzweig, Director, Advanced Management Seminar, College of Business Administration, University of Washington, Seattle 5, Wash.

. . . **23-July 2**—15th Annual Quality Control for Chemical Industries, Rochester Institute of Technology, Rochester, N. Y., contact Robert D. Pease, Associate Director, Evening Division, Rochester Institute of Technology, 65 Plymouth Avenue South, Rochester 8, N. Y.

POSITIONS WANTED

Address all replies to box number references to: American Society for Quality Control, Room 6197 Plankinton Bldg., 161 W. Wisconsin Ave., Milwaukee, Wis.

Quality Control Engineer, age 30, desires position of supervisory or administrative nature in New Jersey or Metropolitan New York. College degree with advanced studies in Statistical Quality Control. Seven years experience in the application of SQC in manufacture of electronic devices and precision aircraft components, familiar with government specifications and all phases of nondestructive testing and inspection. Detailed resume available at Box 14J1 at the above address.

Quality Control

Presently employed major corporation, desires relocation East Coast. Fellow ASQC; graduate engineer with training in advanced statistics, precision measurements, NDT, etc. Fifteen years successful organization and administration of multi-plant inspection & quality control in mechanical and process industries. Please request resume by addressing Box 14J2 at the above address.

Vendor Quality Representative for New York State area. Will consider multiple representation at a fixed fee per assignment. Have varied and lengthy experience with major contractors in electronics assemblies. Please reply to Box 14J3 at the above address.

CONSULTING SERVICES

Responsibility of the American Society for Quality Control, Inc., for Consulting Services advertising is limited to certification that advertisers hold the grade of membership in the Society stated in their advertisements. Qualification requirements for the several grades of membership are set forth in the Constitution of the Society.

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Prompt notification of a change of address enables us to correct your records at the Headquarters Office, correct your mailing address for *Industrial Quality Control*, and notify your section to correct their mailing list. Therefore, if you move, fill out this form and mail to ASQC, 161 W. Wisconsin Ave., Milwaukee 3, Wis.

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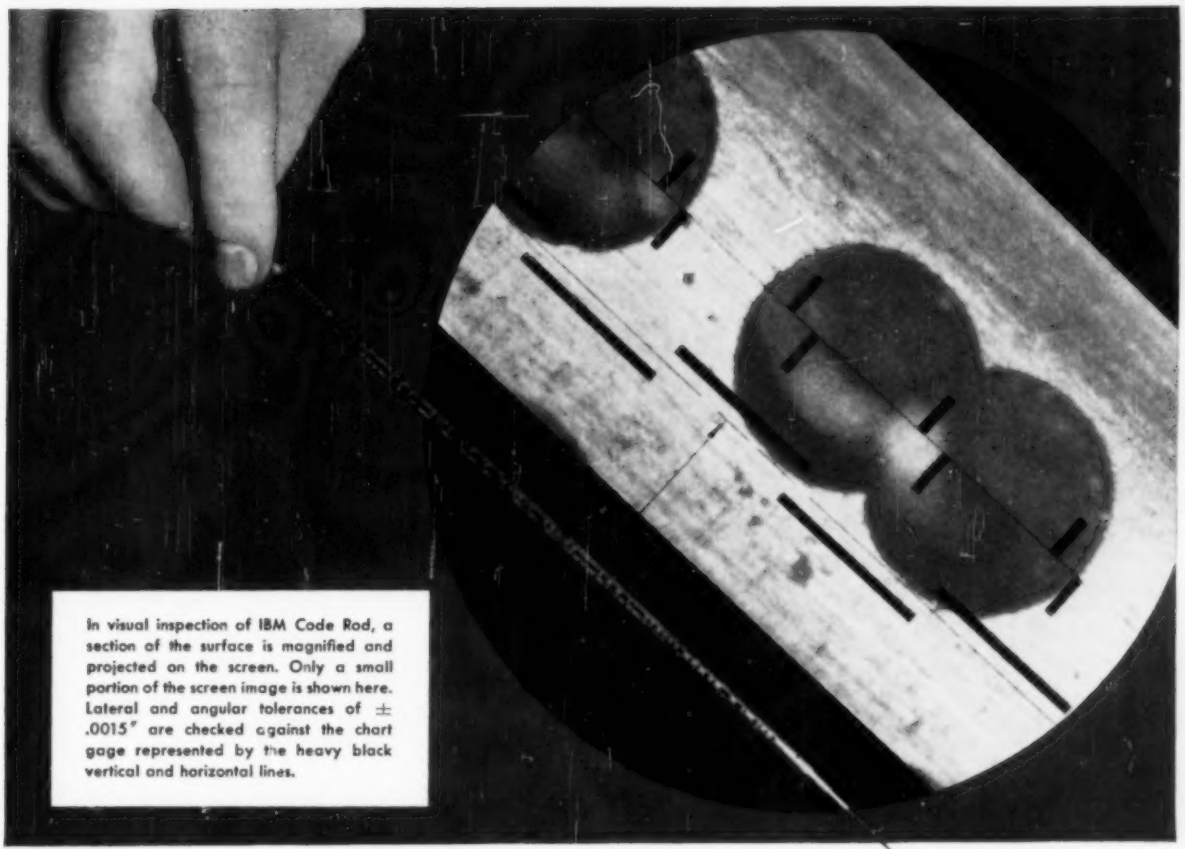
IMPORTANT: Please do **not** use ball point or other dye-type inks. This form will be Thermofaxed and thus requires pencil, metallic-base inks or typewriters. 3-58



In visual inspection of IBM Code Rod, a section of the surface is magnified and projected on the screen. Only a small portion of the screen image is shown here. Lateral and angular tolerances of ± .0015″ are checked against the chart gage represented by the heavy black vertical and horizontal lines.

How would you gage these 1,118 holes?

Here's how IBM did it... and smashed an inspection bottleneck

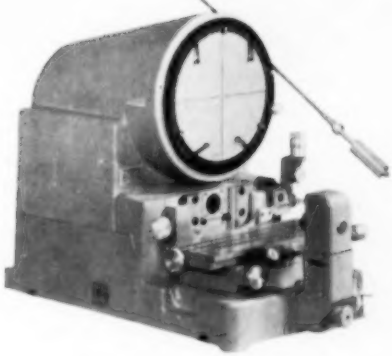
Here's how International Business Machines Corporation boosted the inspection rate on its new Code Rod from 1 or 2 *per day* to 15-20 *per shift*—keeping pace with production, yet maintaining complete accuracy—with a Kodak Contour Projector, Model 14-2A.

The Code Rod is used with the new 720 High Speed Wire Printer, developed by IBM to overcome the speed limitations of conventional bar type printers. The rod is a stainless steel tube with no less than 1,118 1/32″ holes. The holes are drilled in various combinations at 7 different intervals in 7 straight rows down the 8″ length of the tube. Obviously the inspection problem is of no small proportions.

Lateral and angular tolerances for the holes are ± .0015″. *To maintain these tolerances is critical because any mis-drilled holes would cause an error in the shape of the characters to be printed.* What's more, the 720 Printer operates at extremely high speeds, and any slight error could affect its operation.

In visual inspection a master Code Rod is placed next to the rod to be inspected. Both surface images are projected on the screen. The operator simply indexes the image along simultaneously, so that he always has a correct rod in view for comparison of the hole grouping. He checks tolerances by a chart gage on the projector screen.

Got an inspection bottleneck at your plant? Optical gaging with a Kodak Contour Projector may well be the answer. The booklet "Kodak Contour Projectors" gives examples of how other firms are profitably using Kodak Contour Projectors, plus full data on the various models we offer. The booklet is available on request from:



Kodak Contour Projector, Model 14-2A, is a versatile precision measuring instrument for production lines or toolroom. It is one of 6 Kodak Contour Projector models available to meet all your optical gaging needs. Operators work in complete comfort, need little training.

Apparatus and Optical Division

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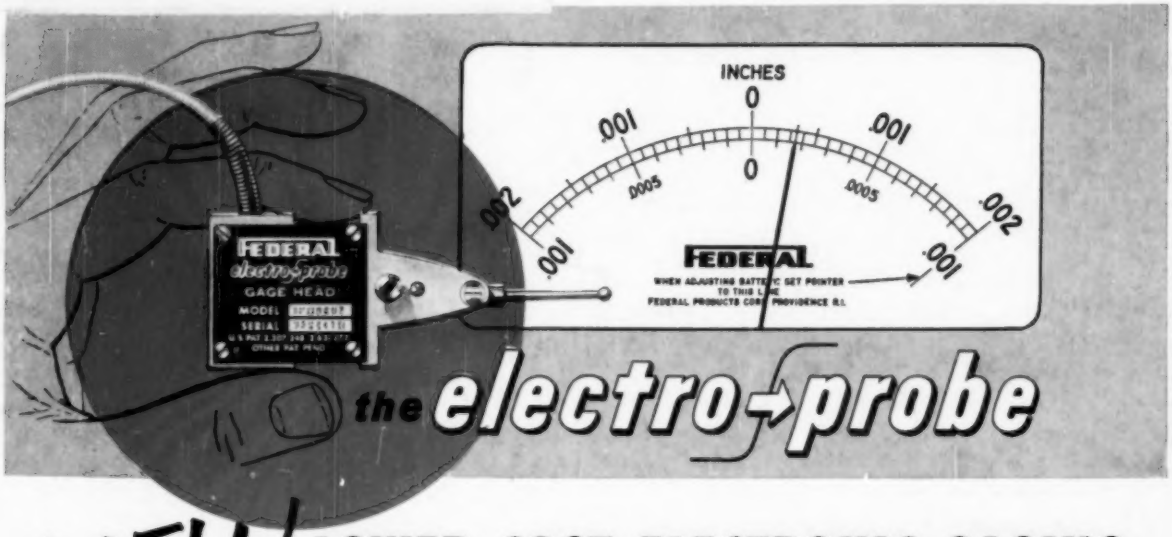
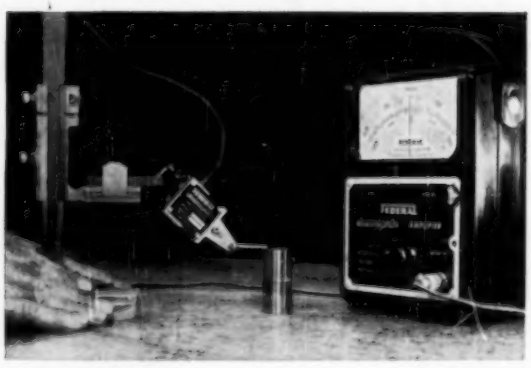


NEW LOWER COST ELECTRONIC GAGING

The new Electro-Probe Model 230 P-2 introduces a new concept in Dimensional Control. It is far more than just another electronic test indicator.



1. Take it anywhere. Model 230 P-2 is completely portable and self-contained. It consists of a bantam size electronic gage head and transistor amplifier which, with metal carrying case and accessories, weighs only 8½ lbs. It is completely independent of external power, and electrical parts are hermetically sealed.

2. Mount it on any conventional fixture. No special stand or holding fixture is required because gaging pressure is extremely light (less than 2.5 grams). Supports which would deflect under even normally light gaging pressures remain rigid when the Electro-Probe is used. And the gaging pressure remains constant throughout range (change is less than 0.1 gram per .001").

3. Set it up in a jiffy. Now you have Precision *without* time-consuming adjustments. Master it anywhere within its range because response is so linear. Full scale Zero Adjustment makes positioning easy and fast. Warm up time is virtually zero. Gage when *you're* ready!

4. Gage with ease and assurance. Contact has friction-free travel of ± .015". Clutch mounting allows head to be placed in almost any position and provides complete over-travel protection. Either of two magnifications instantly available. Wide 4½" dial easy to read.

5. Enjoy greater reliability than ever before. Use of **Printed circuits** and **transistors** means trouble-free performance. Connections are sure, operating current amazingly low — no heating or voltage regulation problems, no dependence on electrical outlets. Learn more about this truly portable, reliable, accurate and versatile gaging device.

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